GROUND AND SURFACE WATER INTERACTION RELATED TO NUTRIENTS WITHIN MASON CREEK AGRICULTURAL DRAIN

CANYON COUNTY, IDAHO

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Ground Water Monitoring Technical Completion Report

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Cover Picture: Confluence of Mason Creek with the Boise River, June 2002.

Abstract

In 2000, the Idaho Department of Environmental Quality allocated Federal Clean Water Act Section 319 money to the Idaho State Department of Agriculture (ISDA) to study surface and ground water interaction in the lower Boise River Basin at a small scale. The study was initiated as a result of degradation of the surface and ground water systems in the basin due to excessive amounts of phosphorous and nitrogen entering the system over the past several decades. A further purpose of the investigation was to gain a better technical understanding of the system to provide input for the Environmental Protection Agency required Total Maximum Daily Loads for phosphorous in streams of the basin.

Two sites along Mason Creek in Canyon County were selected for the study. A network of monitoring wells was established in June 2000 at each site and subsequent monitoring and field-work were performed through December 2001. Monthly collection of water quality data, physical measurements of the ground and surface water system, historical data, and other on-site work provided the basis for the evaluation. Data gathered from the sites provided inputs to hydrogeologically characterize and statistically/mathematically evaluate the ground and surface water interaction at the sites.

At the upstream site (approximately five miles from the confluence with the Boise River), the study indicated that the upper extent of the ground water system was hydraulically connected and seasonally contributed both phosphorous and nitrate-nitrogen (NO_3-N) to the drain. Static water level measurements showed ground water to be less than six feet below land surface and contouring indicated ground water flow to interact with Mason Creek. Flow measurements indicated that at the site Mason Creek drain potentially was gaining water during January to May 2001 and losing water during June to November 2001. Average ground water NO_3-N concentrations (9.25 milligrams per liter) and orthophosphorous concentrations (0.35 milligrams per liter) were typically three-fold higher than those measured in the drain. Over a nine-month period for which loads were determined, ground water was estimated to potentially contribute 437 pounds of NO_3-N to Mason Creek. During the same nine-month period, it was determined that Mason Creek contributed 228 pounds of orthophosphorous to the ground water at the site. During the gaining periods of Mason Creek at the upstream site the average daily contribution of NO_3-N and orthophosphorous from the ground water was 72 pounds/day and 2.5 pounds/day, respectively. The daily contributions of NO_3-N from the ground water accounted for seven percent to ten percent of the instantaneous NO_3-N load of Mason Creek at the upstream site. The daily contributions of orthophosphorous from the ground water accounted for four percent to seven percent of the instantaneous orthophosphorous load of Mason Creek at the upstream site.

At the down stream site (approximately one mile from the confluence with the Boise River), the study indicated that the upper extent of the ground water system also was hydraulically connected and seasonally contributed both phosphorous and NO_3-N to Mason Creek. Static water level measurements indicated ground water to be less than six feet below land surface and contouring indicated ground water flow to interact with the drain. Flow calculations indicated the site potentially was contributing ground water to Mason Creek drain during January through May 2001 and October through November 2001; and losing drainage water to the shallow

aquifer during June through August 2001. Average ground water NO_3-N concentrations (4.65 milligrams per liter) and orthophosphorous concentrations (0.33 milligrams per liter) were typically 1.5 times higher than those measured in the drain. Over a nine-month period for which loads were determined, ground water was estimated to potentially contribute 17,096 pounds of NO_3-N and 650 pounds of orthophosphorous to Mason Creek at the site. During the gaining periods of Mason Creek at the downstream site the average daily contribution of NO_3-N and orthophosphorous from the ground water was 130 pounds/day and 7.4 pounds/day, respectively. The daily contributions of NO_3-N from the ground water accounted for eight percent to ten percent of the instantaneous NO_3-N load of Mason Creek at the downstream site. The daily contributions of orthophosphorous from the ground water accounted for 10 percent to 12 percent of the instantaneous orthophosphorous load of Mason Creek at the downstream site.

Introduction

Water quality in the lower Boise River basin steadily deteriorates between Boise and the confluence with the Snake River. Major contaminants of concern include nutrients (phosphorous and nitrogen), suspended sediment, bacteria, and temperature. Agricultural drains and natural tributaries are among the pathways that provide contaminants to the river.

Mason Creek drain is one of several lower Boise River tributaries with elevated nitrate-nitrogen (NO_3-N) and orthophosphorous concentrations as determined by Idaho State Department of Agriculture (ISDA) drain monitoring conducted in 1998 and 1999. This is supported by prior monitoring conducted by the United States Geological Survey (USGS) in 1994 through 1997 (Mullins, 1998). Data from Idaho Department of Water Resources (IDWR) Statewide Ambient Ground Water Monitoring Program (Neely and Crockett, 1998) also indicate elevated NO_3-N in ground water with a median NO_3-N value of 3.87 milligrams per liter (mg/L). Analyses of surface water quality indicate a dissolved phosphorous and nitrogen component, but the sources of that component have not been quantified. Substantial non-irrigation season flow in Mason Creek drain suggests a significant component of ground water discharge to the drain.

Mason Creek drain was selected by ISDA for study to (1) evaluate ground water and surface interaction to help determine the influence of ground water quality on the drain and eventual impacts to the lower Boise River and (2) provide input to the writing and implementation of a nutrient Total Maximum Daily Load (TMDL) by the Idaho Department of Environmental (IDEQ) for the lower Boise River. Additionally, information was gathered during the course of the study to evaluate potential impacts from on-site and nearby agricultural fields and determine if agricultural Best Management Practices (BMP) are needed for ground water and surface water protection. Project monitoring efforts began in July 2000 and were completed in December 2001.

Scope

The purpose of this project was to study ground and surface water interaction of a typical lower Boise River agricultural tributary at a local scale, both physically and chemically. Two separate sites covering approximately 300 feet each of Mason Creek drain frontage were chosen to complete the evaluation. The focus of evaluation were on (1) nutrient concentrations of shallow ground water entering the drain, (2) physical characterization of ground water flow direction and volume based on lithologic and hydrogeologic characterization, (3) physical and chemical properties of the ground water and the drain, (4) nutrient contributions from on-site or nearby farm fields, (5) quantification of ground water quality impacts to the drain and (6) prior hydrogeologic and water quality studies in the vicinity.

Background and Description of Project Area

The Mason Creek drain project sites are situated in Canyon County, Idaho in the central portions of the lower Boise River Basin near the cities of Nampa and Caldwell, Idaho (Figure 1). The lower Boise River Basin lies within the geographic province of the western Snake River Plain

(WSRP). The WSRP is a physiographic lowland that extends from approximately King Hill, Idaho to about 50 miles west of the Idaho-Oregon border. The plain is a structural graben underlain by volcanic rocks and filled with lake, fluvial, and alluvial sediments with intercalated basalts (Othberg, 1994). Both shallow and deep aquifer systems are found in the WSRP and underlie both project site locations.

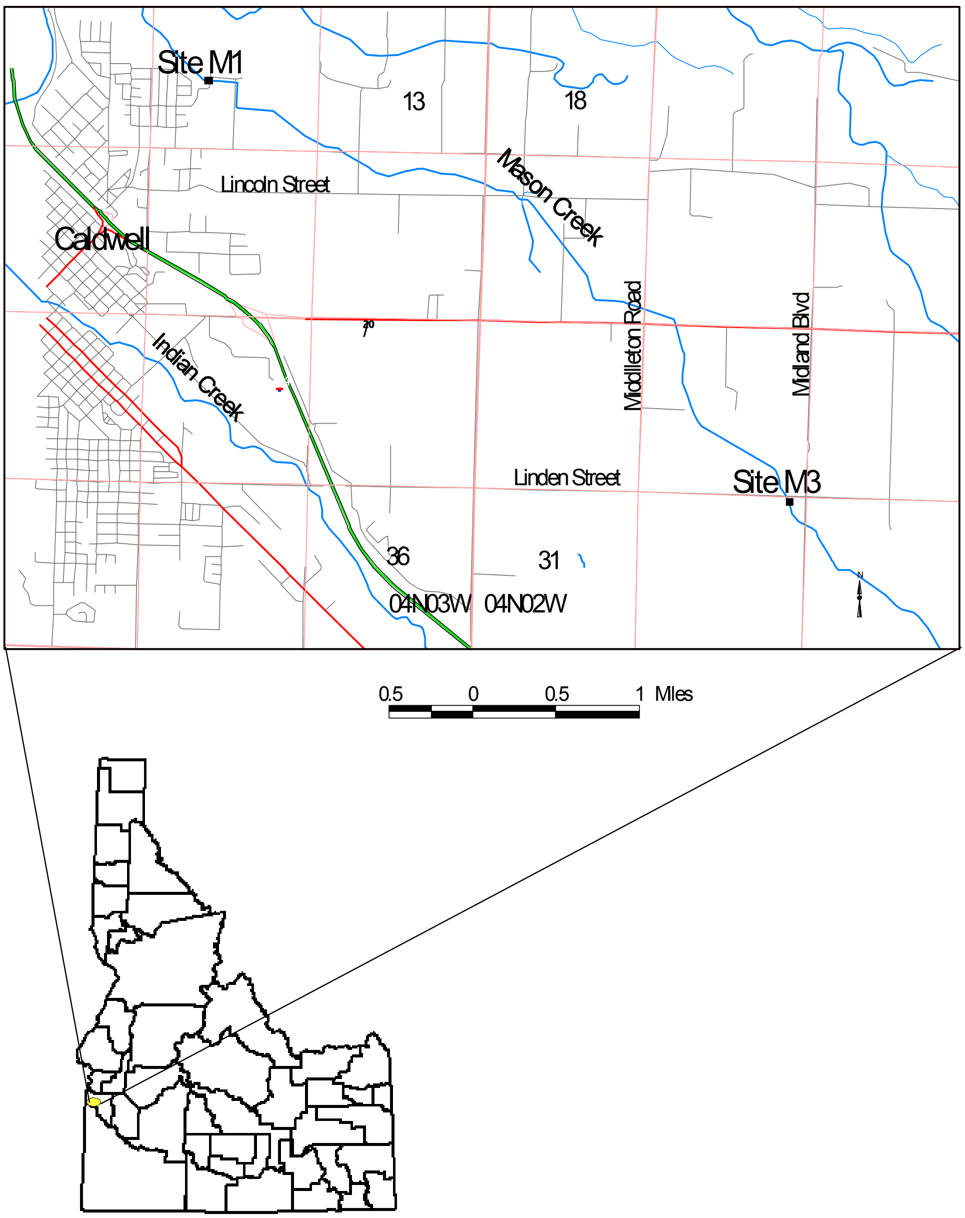


Figure 1. Index map showing locations of Mason Creek Drain project sites.

Mason Creek drain originates from a feeder canal off the New York Canal and flows southwesterly through northeastern Nampa and continues across rural Canyon County before emptying into the Boise River near the northern city limits of Caldwell. Both urban and rural pollutant sources have the potential to negatively affect the water quality of the drain. However, agricultural land uses are the dominant of the two potential pollutant sources and are believed to be the major source of nutrients added to the drain. The predominant nutrient of concern for the drain is phosphorous.

Both row crop agriculture and livestock operations can be found near the drain. Animal operations vary from small numbers of horses, cattle, sheep, and smaller livestock to larger beef and dairy operations. Major crops in the area include potatoes, alfalfa, beans, grain, sugar beets, corn, mint, and irrigated pasture. Average yearly precipitation in the area is approximately 11.9 inches (Mullins, 1998). Thus, irrigation is essential for most crops. Local irrigation systems vary from the historical practice of flood irrigation to more modern techniques of sprinkler irrigation.

The sites are situated within a NO_3-N ground water priority area designated by IDEQ. The priority area was established as a result of 25 percent of ground water samples in the area exceeding 5 mg/L for NO_3-N. Based on a ranking system developed by IDEQ in conjunction with the Idaho Ground Water Monitoring Technical Committee, the area has been ranked as the 4th highest priority area in the state out of a total of 25 areas. Detrimental impacts to ground water in the area are believed to be land use driven by and related to agriculture.

Previous Investigations

Previous Work on Geology and Hydrogeology in Project Area

Dion (1972) described a complex geologic history of erosion, sedimentation, and episodes of volcanic activity in the area. Dion (1972) described important shallow aquifers in the Tenmile gravels and Quaternary alluvium and documented that recharge to the shallow aquifers is mainly from leakage of irrigation canals and laterals, downward percolation of applied irrigation water and precipitation, and downward percolation of domestic wastewater from septic tanks.

Wood and Anderson (1981) provided interpretations of the J.N. James No. 1 well log, an approximate 14,100 feet deep well drilled near Meridian. Using the well logs from several other shallower wells, Wood and Anderson (1981) developed a general stratigraphy of Cenozoic rocks beneath the Nampa-Caldwell-Meridian area.

Anderson and Wood (1981) described three shallow aquifers in highly permeable beds of sand within the Idaho Group. Anderson and Wood (1981) also identified three to five potential deeper permeable water bearing zones. Anderson and Wood (1981) reported deeper zones to be below a thick layer of blue clay, which ranges in thickness from a few feet to over 400 feet in the Nampa-Caldwell area. Petrich et al. (1999) described the blue clay layer as not laterally continuous in the eastern portions of the Treasure Valley. Anderson and Wood (1981) determined that recharge for the deeper system probably originates from the Owyhee Mountains to the south and/or the Idaho batholith to the north.

Othberg (1994) described the Boise Valley geologic history including the great structural basin that contains the study area. Othberg (1994) described the stratigraphy of the Boise Valley, starting with the Pre-Tertiary rocks of the Idaho batholith. Othberg (1994) mapped the upper subsurface stratigraphy as being Quaternary terrace gravels capped by loess.

Petrich et al. (1999) found that the shallow aquifers have transmissivity values of less than 200,000 ft^2/day. Petrich et al. (1999) also determined the deeper aquifers have transmissivities ranging from 200,000 to 400,000 ft^2/day.

Preist et al. (1972) mapped the soils in the Canyon County area. The map indicates that Moulton fine sandy loam and Baldock loam are found at the down stream and upstream site, respectively (Preist et al., 1972).

Previous Work on Phosphorous Contamination in the Project Area

IDWR evaluated 144 shallow wells (less than 360 feet deep) and 137 deep wells (more than 360 feet deep) in the Treasure Valley during 1991 through 1994 for total and orthophosphorous (Neely and Crockett, 1998). Most of the sites sampled during 1991 through 1993 were resampled during 1995 to 1997. During the 1995 to 1997 testing, the samples ranged from <0.01 mg/L (16 wells) to a high of 1.6 mg/L for orthophosphorous. The average phosphorous concentration was 0.04 mg/L. Thirty-nine (14%) of the wells tested had phosphorous concentrations greater than or equal to 0.1 mg/L, 28 of the wells being shallow. A total phosphorous concentration greater than 0.1 mg/L is considered to support nuisance growth of algae and plants in moving surface waters (Mackenthun, 1969, as cited in Mullins, 1998).

Mullins (1998) used 18 surface water samples collected at the mouth of Mason Creek from May 1994 to February 1997 to calculate the total phosphorous concentration and instantaneous phosphorous load. The average total phosphorous concentration was 0.22 mg/L with a maximum concentration of 0.93 mg/L. Mullins (1998) used this data to calculate the instantaneous phosphorous load by using instantaneous discharge and the associated concentration of total phosphorous. The average instantaneous phosphorous load was calculated to be 92 pounds/day, with a maximum instantaneous load of 607 pounds/day. Orthophosphorous concentrations were very similar to total phosphorous concentrations.

ISDA collected surface water samples for phosphorous analysis at five stations along Mason Creek in 1998 and 1999. The total phosphorous concentrations ranged from 0.10 mg/L during the non-irrigation season to 0.71 mg/L during the irrigation season. The average total phosphorous concentration ranged from 0.19 mg/L near the headwaters to 0.41 mg/L near the mouth during the irrigation season. The total phosphorous concentration increased in a downstream direction during the irrigation season. During the non-irrigation season, the average concentrations ranged from 0.18 mg/L near the headwaters, to a high of 0.27 mg/L near the mouth. The dissolved orthophosphorous concentrations were typically 65% to 75% of the total phosphorous concentrations.

Previous Work on Nitrate-Nitrogen Contamination in the Project Area

Parliman et al. (1996) analyzed 335 ground water samples taken from July 1995 through October 1995 in the lower Boise River area. They found 10 wells (3%) had NO_3-N concentrations over the Environmental Protection Agency (EPA) Maximum Contaminate Level (MCL) of 10 mg/L. All wells that had NO_3-N concentrations greater than 10 mg/L were less than 150 feet deep. Fifty percent of the wells had NO_3-N concentrations ranging from 2 to 10 mg/L (Parliman et al., 1996).

Neely and Crockett (1998) evaluated NO_3-N values in the Treasure Valley from wells sampled in 1991 through 1994 and again in 1995 through 1997. During 1991 through 1994, 144 shallow wells (less than 360 feet deep) and 137 deep wells (more than 360 feet deep) were sampled. Neely and Crockett (1998) found that NO_3-N concentrations in 1995 through 1997 had increased in 72% of the shallow wells that were sampled in both events. The increases ranged from 0.03 to 11.20 mg/L. The median value increased from 3.35 to 3.87 mg/L. Six (4%) of the wells sampled in 1995 through 1997 had NO_3-N concentrations over the EPA MCL of 10 mg/L. NO_3-N concentrations increased in 40% of the deep wells sampled. The average value of deep wells decreased from 0.87 mg/L to 0.69 mg/L. Two deep wells had NO_3-N concentrations above the EPA MCL of 10 mg/L. A significant difference was found between the average ground water NO_3-N concentration of agricultural land (3.70 mg/L) and urban land (1.95 mg/L).

Mullins (1998) used 18 surface water samples collected at the mouth of Mason Creek from May 1994 to February 1997 to calculate the total NO_3-N concentration and instantaneous NO_3-N discharge. The average total NO_3-N concentration was 4.7 mg/L with a maximum concentration of 6.9 mg/L. Mullins (1998) calculated the average instantaneous NO_3-N load to be 2,770 pounds/day with a maximum instantaneous load of 3,520 pounds/day. The average instantaneous load value of 2,770 pounds/day is comparable to the West Boise Waste Water Treatment Facility NO_3-N load of over 2,000 pounds/day. The tributaries and drains on the south side of the Boise River (Mason Creek included) contributed the most amount of discharge and total NO_3-N to the Boise River during low flow sampling periods (Mullins, 1998).

Methods

Site Selection and Location

Two project sites were selected for installation of ground water monitoring wells, future surface and ground water monitoring, and other related research activities based on (1) prior ISDA surface water quality data, (2) land owner permission, (3) accessibility and (4) local agricultural land use. The sites, located near prior ISDA surface water monitoring locations, subsequently are referred to as Mason Creek 1 (M-1) and Mason Creek 3 (M-3) in accordance with a labeling system devised to assist in sample collection and data record keeping during past ISDA monitoring. The sites selected for this project correspond to those locations and hereafter are referred to as M-1 and M-3. Site M-1 is located in the NE 1/4, sec. 32, T. 4N, R. 2W. Site M-3 is located in the SW 1/4, sec. 14, T. 4N, R. 3W. Refer to Figure 1 for site locations.

Geologic, Hydrogeologic, and Hydrologic Investigations

Interpretation of the local geology and hydrogeology was based on the evaluation of well drillers' reports and on-site lithologic descriptions by ISDA staff. Geologic cross sections of the subsurface geology in the vicinity of both project sites were constructed using the computer software program Well_Log (Baker, 1994).

On-site static water level measurements were taken monthly to determine ground water elevations. Wellhead locations were determined using a Trimble™ Geo Explorer Global Positioning System (GPS). Wellhead elevations were determined using a Sokkia™ Survey Station Model SET5F. Water level elevations were subsequently determined by subtraction of static water level measurements using the wellhead as the elevation reference point. Water level contour maps than were created using Surfer™ based on shallow ground water elevations and GPS locations.

Other aquifer and substrate parameters were determined through on-site slug testing. Measurements were collected using a Solinst™ Level Logger Model 3001 and Micron™ Transport laptop computer. Static water level readings were recorded every 0.5 seconds during the test. These data were plotted on a semi-log graph as head ratio h_t/h_0 against time. The head ratio was calculated by dividing the water displacement at time t (h_t) by the maximum water displacement immediately after the slug was dropped (h_0). The Hvorslev method was used to estimate hydraulic conductivity. Calculated hydraulic conductivities were then used to calculate ground water flow estimates.

On site stream measurements were completed monthly at upstream and downstream locations at both M-1 and M-3 to determine average velocities, flow, and to determine nutrient loading. Measurements were completed with a Marsh McBirney™ Model 2000 Flow Meter and average velocities determined using the Six-Tenths Method. Appropriate mathematical equations were then used to determine flow and nutrient loads.

Monitoring Network Designs, Nutrient Sampling, and Other Field Measurements

General monitoring network layout and well construction design was implemented based on consultation with Dr. James Osiensky, Associate Professor of Hydrogeology of the University of Idaho and Joe Spinazola, Hydrogeologist with the Bureau of Reclamation (BOR). In planning monitoring network design, the physical aquifer characterization (i.e., gradient, flow direction, etc.) as well as water quality characterization were considered. Alteration of the original monitoring network designs was necessary for one or more of the following reasons: (1) request of landowners, (2) access constraints, and (3) request of the irrigation district canal company.

A total of eight shallow depth wells (less than 25 feet), four intermediate depth wells (25 feet to 40 feet) and one deep well (117 feet) were installed at M-1. Alteration of the original monitoring network design plan was completed at the request of the landowner that no well be located within central portions of his pasture.

A total of eight shallow depth wells (less than 25 feet), four intermediate depth wells (25 feet to 55 feet), and two deep wells (93 and 153 feet) were installed at M-3. Alteration of the original monitoring design plan was completed due to a request by the Pioneer District Canal Company that no wells be located within 50 feet of the center of the canal on either side to allow canal company access.

Shallow and intermediate depth monitoring wells were constructed using a six-inch hollow-stem auger owned by the BOR and operated by BOR drilling staff. Monitoring wells were completed with two-inch diameter PVC with a five-foot sump of blank casing capped at the bottom, five feet of 0.010 slotted well screen, and blank casing to about two feet above land surface. Annulus from approximately one foot above the top of the slotted screen to the bottom sump was gravel packed. The remainder of annulus was backfilled with bentonite chips. A locking standpipe was placed over each well.

Deep wells were constructed using a six-inch air rotary drill owned by the BOR and operated by BOR drilling staff. Wells were constructed similar to shallow and intermediate wells with the exception that the annulus above the screen pack was grouted with bentonite slurry.

Ground water and surface water samples were collected monthly by ISDA and analyzed for NO_3-N, total phosphorous, and orthophosphorous by the Analytical Sciences Laboratory in Boise, Idaho using EPA methods 353.2, 365.1, and 365.4, respectively. All water samples were taken following ISDA standard operating procedures (SOPs) for collection, shipping, handling, and chain of custody. Protocol documents are on file at the ISDA Boise Office. Field parameters also were collected monthly during the time of water sample collection. Field parameter measurements included the following: specific conductivity, total dissolved solids, pH, and temperature measurements. All field measurements were collected using ISDA SOPs.

Nitrogen isotope testing was completed in December 2000 to help determine potential sources of contaminants entering ground water. Samples were collected from all wells following ISDA SOPs. Samples were frozen and shipped via Federal Express one-day service to the ^{15}N Analysis Service, Department of NRES, University of Illinois Champaign-Urbana.

A one-time interval soil sampling of nutrients also was conducted at several locations at each site. The samples were collected using a two-inch auger and taken to Western Labs in Parma, Idaho for analysis of NO_3-N, phosphorous, and potassium. Collection, shipping, handling, and chain of custody adhered to ISDA SOPs.

Statistical analysis of NO_3-N and phosphorous data was, in part, completed using Microsoft Excel™. Excel statistical software was used for statistical regression models, basic descriptive statistics, time-series, and scatter plots analysis.

Geology

Regional Geologic Overview

The lower Boise River Basin, including Mason Creek drain, is located within the western Snake River Plain (WSRP) geographic province (Figure 2). The Snake River Plain is physiographically continuous from Eastern Oregon to Yellowstone National Park, but is separated into western and eastern portions based on the geology and tectonic origin (Othberg, 1994). A major geologic difference between the west and the east provinces is the upper portions of the WSRP basin is mainly sediment fill, while the upper portion of the eastern Snake River Plain is composed of Quaternary basalt (Wood and Anderson, 1981).

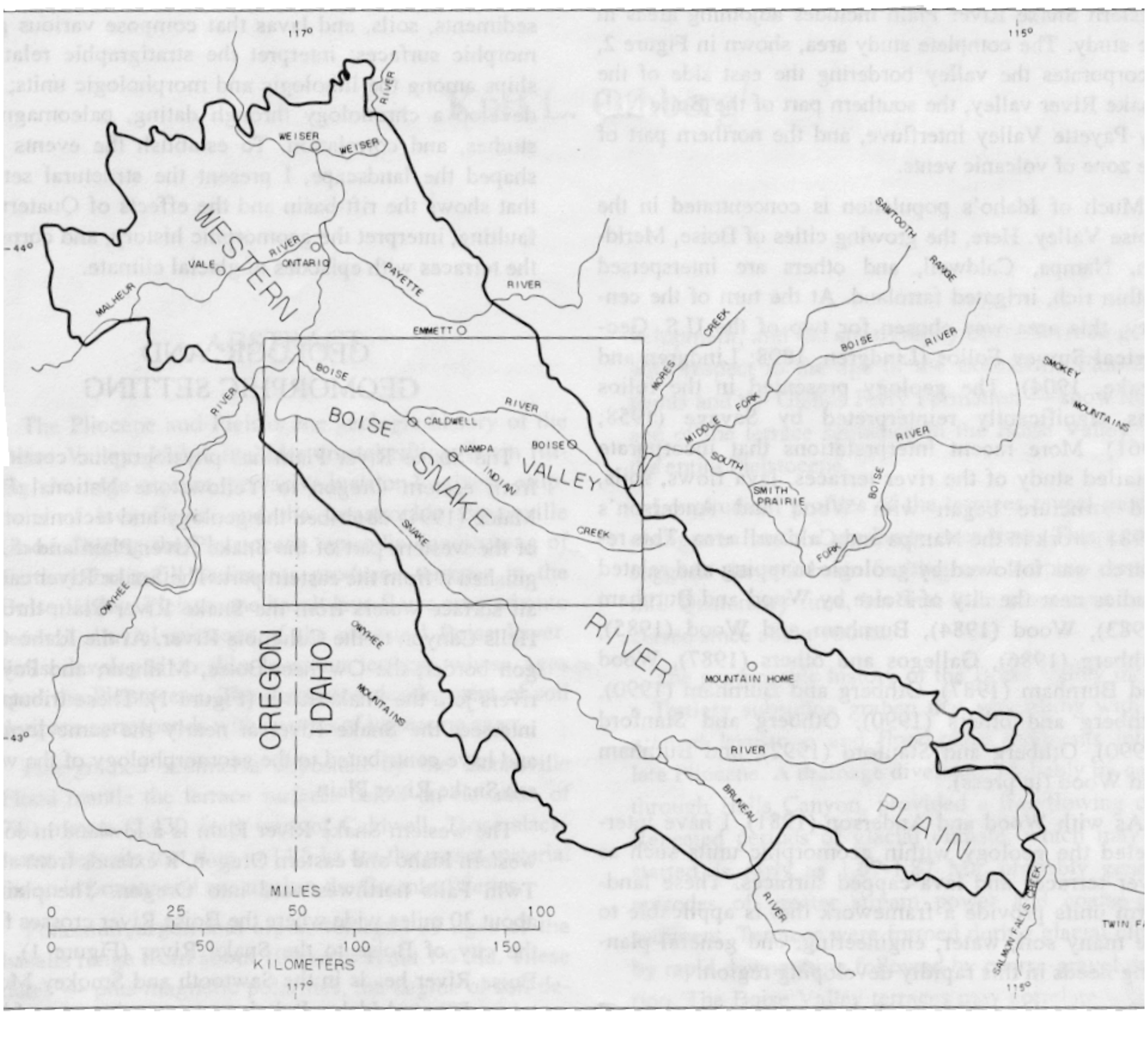


Figure 2. Map showing location of Boise Valley and western Snake River Plain (after Othberg, 1994).

The WSRP is a northwest trending physiographic lowland as well as a great structural basin separating the Cretaceous Idaho Batholith of west central Idaho from batholith outliers in southwest Idaho (Wood and Anderson, 1981; Othberg, 1994). The WSRP is geographically located west of Twin Falls and extends northwestward into Oregon. It is approximately 30 miles wide in the vicinity of Boise, Idaho (Othberg, 1994). The marginal faults of the WSRP trend northwest to southeast and are faulted down toward the center of the basin (Othberg, 1994). Few faults can be seen on the surface, but are shown on geologic cross sections or implied by numerous hot springs in some areas (Parliman, 1983). The early-middle Pliocene faults in the northern portion of the WSRP are displaced a maximum of 9,000 feet with deformation probably beginning between the Miocene and Pleistocene (Othberg, 1994).

Approximately 17 million years ago the subsiding basin of the WSRP began filling with basalt and sediments from surrounding areas with possible silicic eruptions covering portions of the basin 11 million years ago (Othberg, 1994). Sediments within the basin are lacustrine origin, which is evidence for the formation of Lake Idaho, a large lake system that developed within the basin (Wood, 2001). A drainage outlet for the basin is believed to have existed to the west through eastern Oregon during the Tertiary (Othberg, 1994; Boyle, 1996). The drainage is thought to have been episodic and created a widespread filling of the basin with both sediments and basalts from the late Miocene through the late Pliocene (Othberg, 1994). The basin-fill sediments and volcanic flows have been drilled as deep as 2.7 miles without striking basement rock (Wood and Anderson, 1981).

Regional Stratigraphy

Deep subsurface stratigraphy is based off previous studies within the general project area. Figure 3 is a summary of several previous authors interpreted stratigraphy of the Boise Valley units. Most of the regional units are considered continuous, and underlie the project area. For consistency, the unit names given by Woods and Burnham (1983) are used in this report.

Tertiary

The Idaho Group overlies basalt units and is approximately located 250 to 2500 feet below the ground surface in the Boise Valley (Wood and Anderson, 1981). The Idaho Group is broken into a lower and an upper group; the Lower Idaho Group is approximately 1500 feet thick and the Upper Idaho Group is approximately 750 feet thick (Wood and Anderson, 1981). The Upper Idaho group consists of sediments deposited in a sedimentary basin (Wood and Anderson, 1981). The Upper Idaho Group is consistent with the Glenns Ferry Formation as described by Dion (1972). A regional "blue clay layer" occurs in the middle of the Glenns Ferry Formation, and separates the regional shallow and deep aquifer systems (Anderson and Wood, 1981).

Quaternary

In the Nampa-Caldwell area, the Upper Idaho Group is overlain by a fluvial gravel deposit called the Tenmile Gravels (Wood and Anderson, 1981). The gravel is composed of granitic rocks and felsic porhyries deposited by the Boise River (Dion, 1972; Wood and Anderson, 1981). The thickness in the Nampa-Caldwell area rarely exceeds 50 feet (Wood and Anderson, 1981).

The Tenmile Gravels are overlain by four different units: Sediments of the Deer Flat Surface, Gowen Terrace alluvium, Sunrise Terrace alluvium, and Whitney Terrace alluvium; collectively referred to as the Snake River Group. The Snake River Group is composed of relatively thin unaltered olivine basalt flows, fluviatile deposits, and to a lesser extent lacustrine deposits (Dion, 1972; Wood and Anderson, 1981). The Snake River Group is found from 0 to 250 feet below the surface within the study area (Dion, 1972; Wood and Anderson, 1981).

Period	Wood & Burnham (1983)	Savage (1958)	Lindgren & Drake (1904)	Lindgren (1898)
Quaternary	Whitney Terrace Alluvium	Nampa-Caldwell Sediments	Late Terrace Gravels	Lower Mesa Gravel
	Sunrise Terrace Alluvium			
	Gowen Terrace Alluvium	Tenmile Gravel	Early Terrace Gravels	Upper Mesa gravel
	Sediments of the Deer Flat Surface			
	Tenmile Gravel	Idaho Formation		
Tertiary	Upper Idaho Group Lower Idaho Group	Payette Formation	Payette and Idaho Formations undivided	Payette Formation (Payette Gravels)

Figure 3. Late Cenezoic stratigraphy in the Boise Valley for sedimentary units; (modified from Othberg, 1994).

Local Geology

Overview

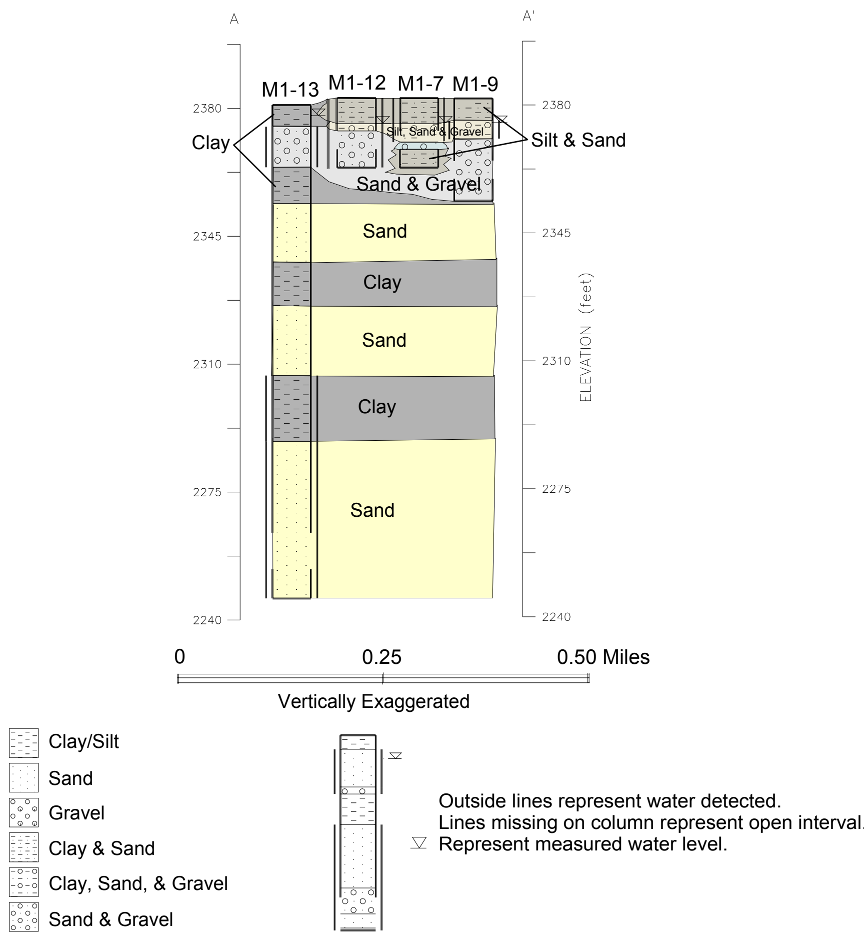
The local geology description for project sites M-1 and M-3 were attained by analyzing the well logs from monitoring wells drilled at M-1 and M-3 by the BOR. The majority of the monitoring wells drilled were shallow, providing detailed geologic data of the 20 feet directly below the ground surface.

All well data were entered into the program WELL_LOG (Baker, 1994) and latitude/longitude data were obtained from GPS coordinates. Cross sections containing the stratigraphic columns were generated with the program WELL_LOG. Units were correlated manually based on the following characteristics: lithologic elevation, lithologic type, water bearing zones, water levels, and predominant lithologic type (e.g., more sand than clay or more clay than sand).

M-1 Geology

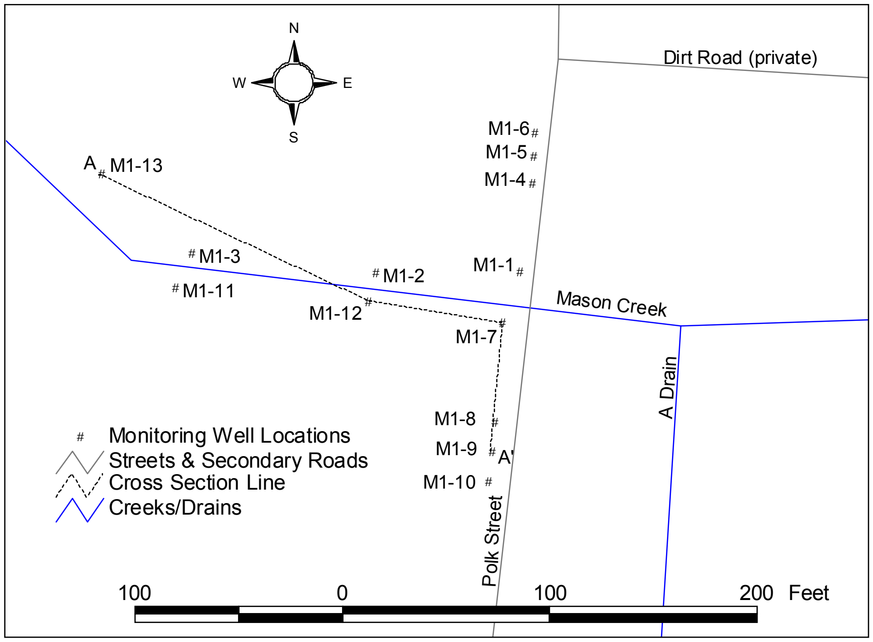
The geologic cross section (Figure 4) constructed for site M-1 was used to analyze the geology. The first 25 feet below topsoils and subsoils is composed dominantly of sands and gravels. These types of sediments correspond closely with the regional stratigraphy of the Quaternary terrace gravels and alluvial deposits of the Snake River Group described by Wood and Anderson (1981). A clay layer is encountered in the intermediate and deep wells. It is found 17 to 28 feet below the ground surface and ranges between 2 and 10 feet thick within the project area. The clay layer is substantially thick enough to form distinct shallow and intermediate hydrogeologic zones below the site. Silt, sand and gravel are found at depths ranging from 27 to 37 feet.

Cuttings from the deepest well (M1-13) indicate alternating sand and clay units from 27 to 135 feet below ground surface. The clay units are between 12 to 18 feet thick while the sand units are between 15 to 20 feet thick. Deeper clay layers appear to be laterally continuous within the site creating confining artesian conditions at M1-13.



a)

Figure 4. a) Geologic cross section for M-1.

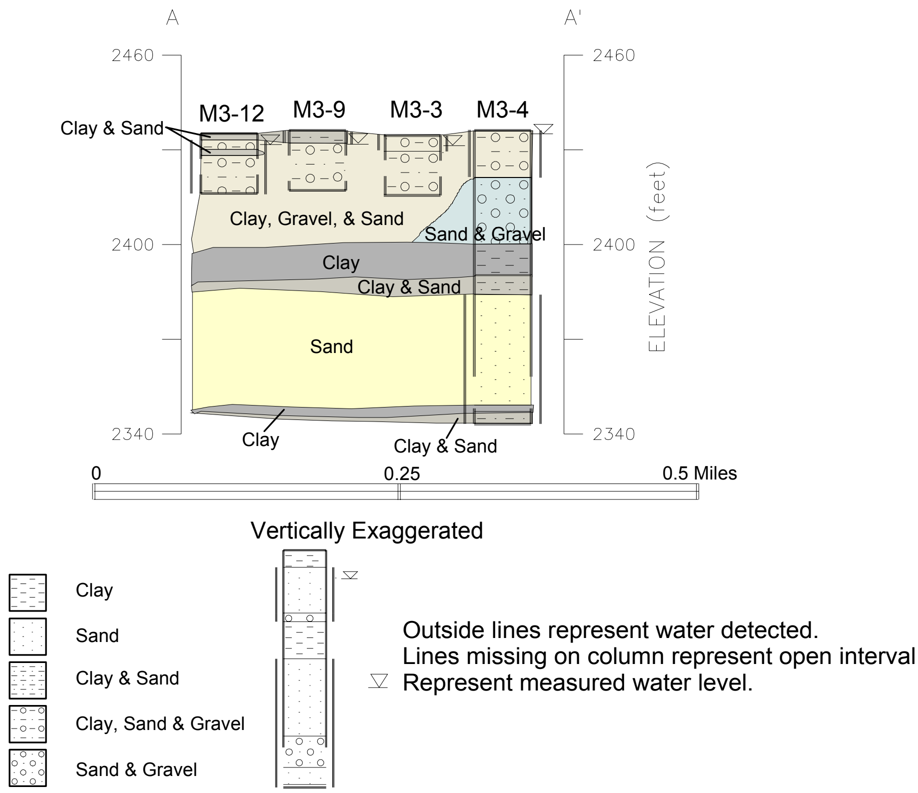


b)

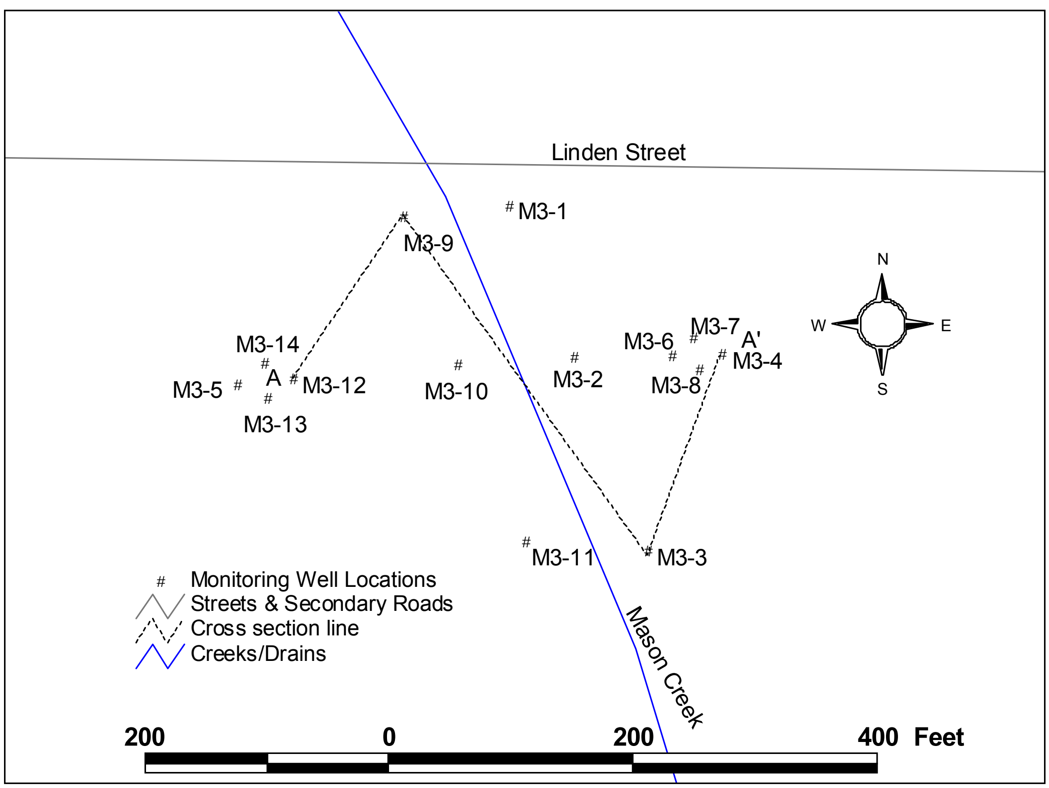
Figure 4. b) Cross section line for M-1.

M-3 Geology

The local geology at site M-3 is not as variable as the geology at site M-1 (Figure 5). There is an apparent laterally continuous layer of clay, sand, gravel and silt between 0 to 37 feet below the ground surface as seen on the cross section in Figure 5. This again probably corresponds to the Quaternary alluvium and fan deposits of the Snake River Group, or possibly the Boise River terrace gravel deposits. A clay layer is located between 36 to 46 feet below ground surface. The clay layer also appears in the deep well M3-8, which is not shown on Figure 5. This clay layer locally appears to separate the shallow unconfined aquifer from intermediate depth water. The deeper wells show a combination of clay and sand layers although less frequent then what is seen at site M-1. The clay layers are probably also lacustrine deposits, while the sand layers are fluviatile deposits. Both clay and sand are probably layers of the Snake River Group. Again, the deeper aquifer system is confined which is indicated by the artesian conditions of the deep wells.



a)



b)

Figure 5. a) Geologic cross section and b) cross section line for M-3.

Soils

Based on U.S. Department of Agriculture soil survey information, Mason Creek flows through three soil series types before emptying into the Boise River. Starting from the headwaters, Mason Creek passes through Power-Potratz type soils, Power-Purdam type soils, and finally Moulton-Bram-Baldock type soils (Priest et al., 1972).

Site M-1 is located on a Moulton fine sandy loam, which is composed of granite, quartz, monzonite, quartz diorite, and related intrusive acid igneous rocks (Priest et al., 1972). The soil is somewhat poorly drained with moderately rapid permeability (Priest et al., 1972).

Site M-3 sits on a Baldock loam, which is thin deposits of calcareous soils along drainage ways and edges of low terraces, derived mainly from granite, basalt, quartz diorite, and old sediments (Priest et al., 1972). This series is somewhat poorly drained with moderate permeability with 1 to 3% slopes (Priest et al., 1972).

Hydrogeology and Hydrology

Lower Boise Basin

Ground Water

The hydrogeology of the project area can be broken into a deep and shallow ground water zones, separated by a blue clay layer. Besides these ground water systems, there are potentially three to five deeper aquifers below the project area (Anderson and Wood, 1981).

Anderson and Wood (1981) described five potential aquifers by correlating lithologic units based on well logs from areas near Caldwell and Meridian. These zones of permeability occur at average depths of 5500 feet, 4300 feet, 3400 feet, 2100 feet, and 1500 feet (Anderson and Wood, 1981).

A major zone of ground water occurs in the lower portion of the Glenns Ferry Formation, under the "blue clay" in the middle of the Glenns Ferry Formation (Anderson and Wood, 1981). The blue clay is believed to be found throughout the project area between the depths of 300 – 700 feet below the ground surface and varies from a thickness of a few feet to a few hundred feet (Petrich et al., 1999). The clay acts as an aquitard separating the shallow aquifers from the deep aquifers (Petrich et al., 1999). The deep aquifer is found in the blue or gray sand directly beneath the blue clay layer (Anderson and Wood, 1981). It is the only significant deep aquifer in the project area (Dion, 1972). The source of recharge for the deep system probably comes from the Owyhee Mountains to the south and/or the Idaho Batholith to the north (Anderson and Wood, 1981). Petrich et al. (1999) calculated transmissivities of the deeper aquifer to range from 200,000 – 400,000 ft^2/day.

A shallow ground water zone occurs in older terrace gravels, basalts of the Snake River Group, younger terrace gravels, and Quaternary alluvium. Recharge to the shallow zone is mainly from leakage of irrigation canals and laterals, downward percolation of applied irrigation water and precipitation, and downward percolation of domestic wastewater from septic tanks (Dion, 1972). Other minor recharge sources include small streams, upward leakage of water from the deep aquifer, and natural leakage of ground water from outside the project area (Dion, 1972). Most of the recharge occurs during April – October, which corresponds with the irrigation season (Dion, 1972). Water level highs occur in early fall (non-irrigated areas usually have high water levels in late spring) and lows occur during the spring (usual lows for non-irrigated areas occur in the fall). Petrich et al. (1999) calculated shallow zone transmissivities of less than 200,000 ft^2/day. Anderson and Wood (1981) divide the shallow system into three subsystems: lower sand, silt and gravel; fractured basalt; and upper sand and gravel.

Surface Water

The headwaters of the lower Boise River begin at the base of Lucky Peak Dam. The river then flows to the west through the city of Boise and continues westward through rural portions of Ada and Canyon Counties before emptying into the Snake River west of Parma. Flow to the river is controlled primarily through reservoir regulation, irrigation withdrawals, irrigation return flows, and losses and gains into shallow ground water of the basin. Thirty diversions divert water from the lower Boise River and 12 major tributaries and drains discharge to the river in the basin (Mullins, 1998). There are a total of 13 irrigation districts and several canal companies within the watershed that divert water from the Boise River into irrigation canals for agricultural use (Koberg and Griswold, 2001). In many cases, pre-existing ephemeral and intermittent channels have been modified for water delivery or drainage for croplands and pastures (Koberg and Griswold, 2001).

Site M-1

Monitoring Network Design and Sampling

A total of eight shallow depth wells (less than 25 feet), four intermediate depth wells (25 feet to 40 feet) and one deep well (117 feet) were installed at M-1. Alteration of the original monitoring network design plan was completed at the request of the landowner that no well be located within central portions of his pasture. Figure 6 is a map of M-1 monitoring well locations.

Drain flow measurements were started in January 2001 and were conducted on a monthly basis through the completion of the study. Flow measurements will aid in the quantification of ground water contributions to the drain. The margin of error of the flow measurements is approximately +/- 5%. Drain flow data is included in Appendix B.

Slug tests were performed on three wells at site M-1 on July 12, 2001. A PVC pipe filled with sand was used as the slug. The change in water level was recorded by a Solinst® Levelogger that was connected to a Micron™ Transport laptop computer to instantaneously download the data.

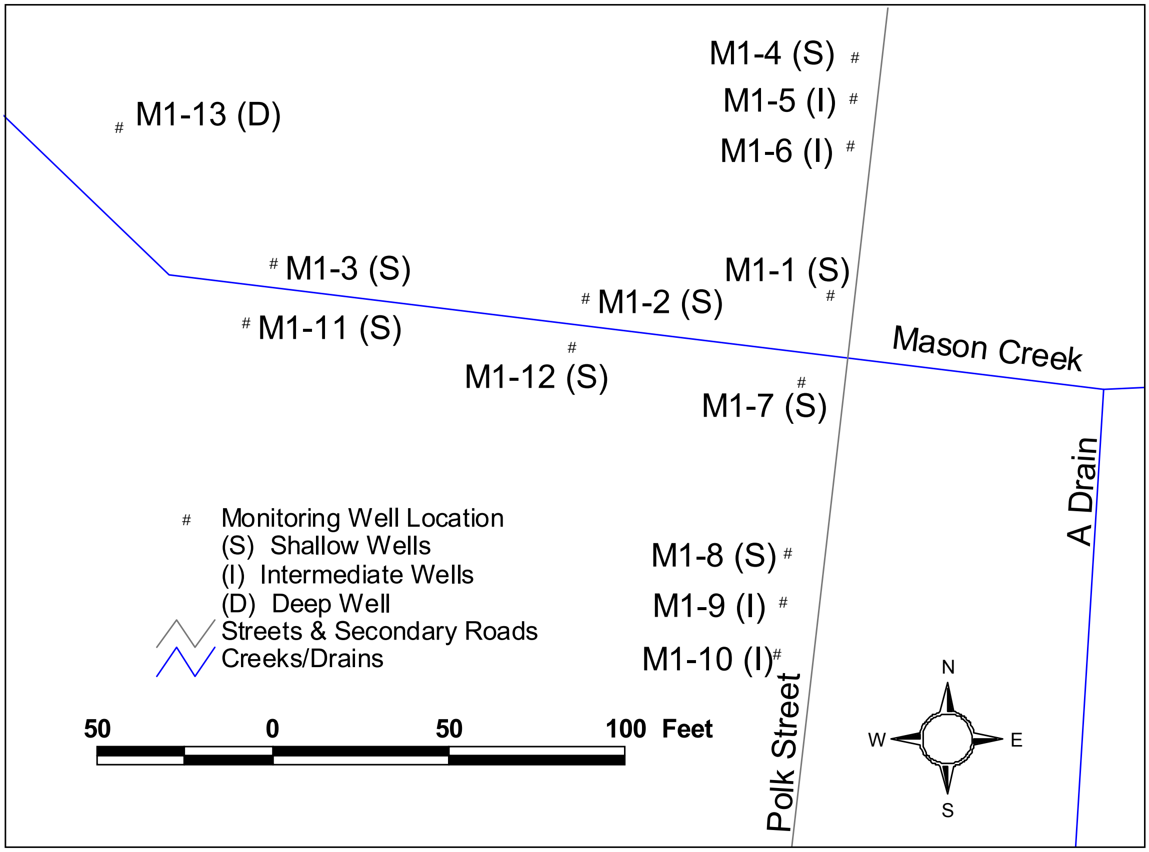


Figure 6. Monitoring well locations of site M-1.

Water Table

Ground water elevation data were used to create water table maps with the computer program Surfer™. Ordinary kriging interpolation was used to make Figure 7. A default linear variogram fit by the program was used for the kriging covariance inputs. July 2000, January 2001 and July 2001 were chosen to display the water table surfaces during wet (January) and dry (July) seasons. January also represents non-irrigation season while July represents irrigation season. Most depth to water measurements were six feet or less below ground surface for the shallow wells. Figure 7 shows the general ground water flow direction of the shallow aquifer is to the north and west. Flow is not greatly effected by the change in weather or irrigation as seen by the similarities of the contour lines for the January and July maps in Figure 7. The direction of ground water flow into Mason Creek in part, combined with the high water table suggests ground water and surface water interaction. Water table maps for site M-1 from July 2000 through December 2001 are included in Appendix E.

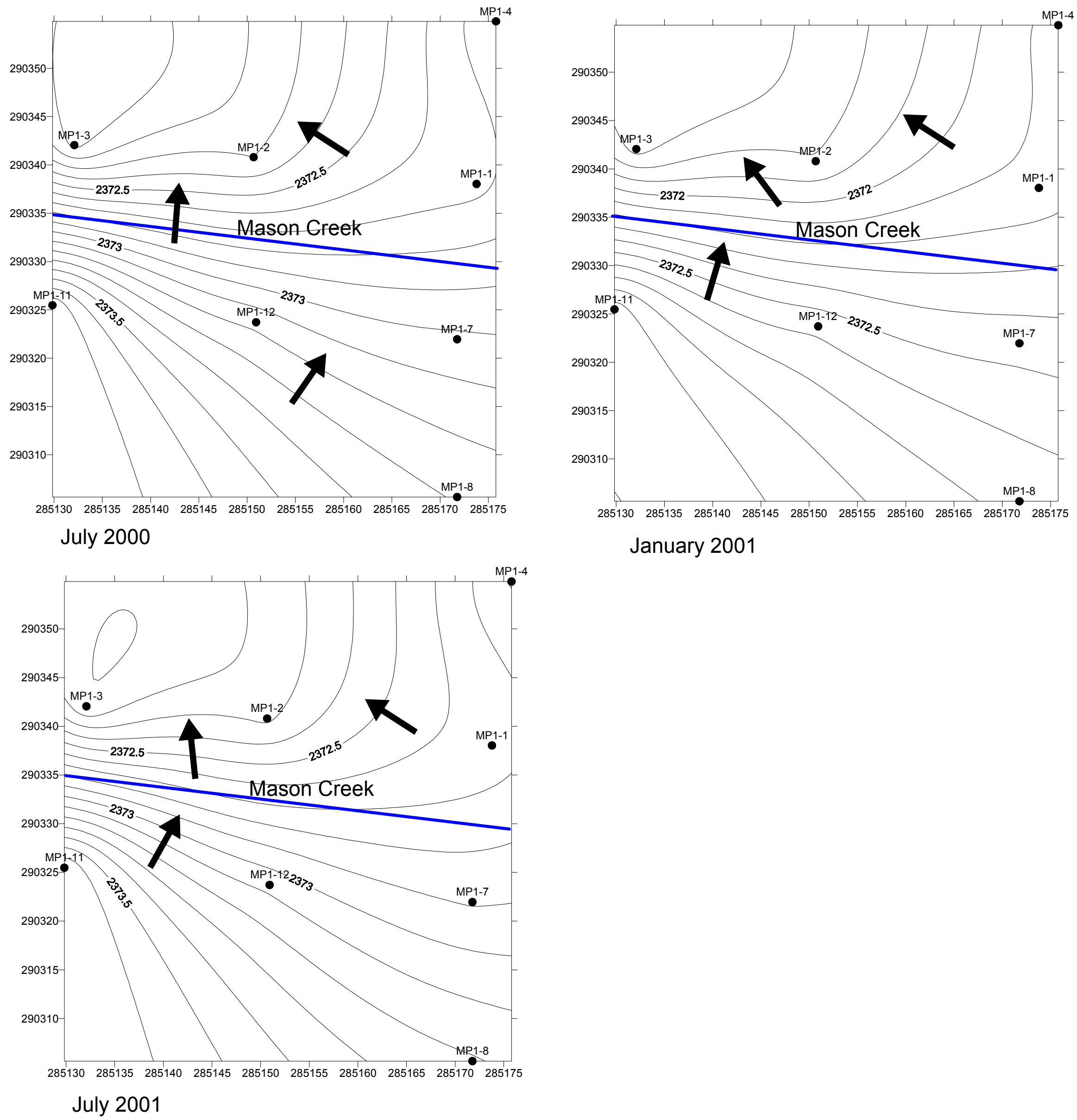


Figure 7. Water table map of M-1 shallow wells with direction of ground water flow.

M-1 Slug Tests

Slug tests were completed on shallow wells at site M-1 on July 12, 2001. A slug was made out of a PVC pipe filled with sand. The pipe was quickly lowered into the well via a rope while the change in water level was recorded by a Solinst® Levelogger that was connected to a laptop to instantaneously download the data. The Hvorslev slug test method was used to determine the hydraulic conductivity of the aquifer. Slug tests were performed on wells M1-1, M1-3 and M1-4. The hydraulic conductivity values for these wells using the Hvorslev method ranged from 123 ft/day to 175 ft/day. The data falls within Fetter's (1994) hydraulic conductivity range for unconsolidated sands and gravels of 28 ft/day to 2835 ft/day. The hydraulic conductivity values were then used to estimate the ground water flow between the upstream and downstream measurement points for discharge (approximately 305 feet apart, see Figure 8). The flow values ranged between 11,255 ft^3/day to 16,013 ft^3/day.

M-1 Stream Measurements

Discharge measurements were taken nine times during 2001. During the irrigation season, downstream discharge measurements at M-1 were somewhat influenced by two small drains that entered Mason Creek above the downstream measurement site. One of the drains could not be measured but its contribution was estimated to be one cubic foot per second or less. At the upstream site on Mason Creek (above the well fields) there was no interference with the discharge measurements. Discharge measurements from the M-1 upstream site ranged from a low of 37.98 cubic feet per second (CFS) during November 2001 to a high of 108.2 CFS during July 2001. Discharge measurements from the M-1 downstream site ranged from a low of 43.85 CFS during November 2001 to a high of 110.2 CFS during July 2001. Discharge measurements of the upstream and downstream locations were used to determine gaining and losing periods of Mason Creek at site M-1. January through May and October through November 2001 were gaining periods of Mason Creek while June through August 2001 were losing periods of Mason Creek at M-1. The locations where the flow measurements were taken are shown on Figure 8.

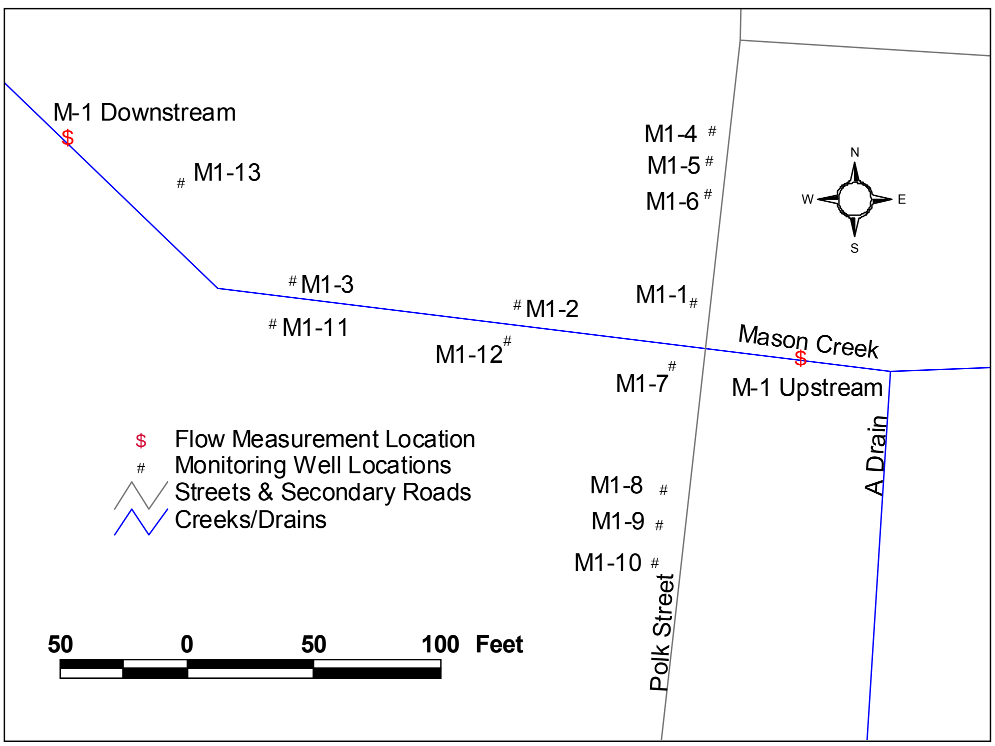


Figure 8. Flow measurement locations for site M-1.

Site M-3

Monitoring Network Design and Sampling

A total of eight shallow depth wells (less than 25 feet), four intermediate depth wells (25 feet to 55 feet), and two deep wells (93 feet and 153 feet) were installed at M-3 (Figure 9). Alteration of the original monitoring design plan was completed at a request by the Pioneer District Canal Company that no wells be located within 50 feet of the center of the canal on either side to allow canal company access.

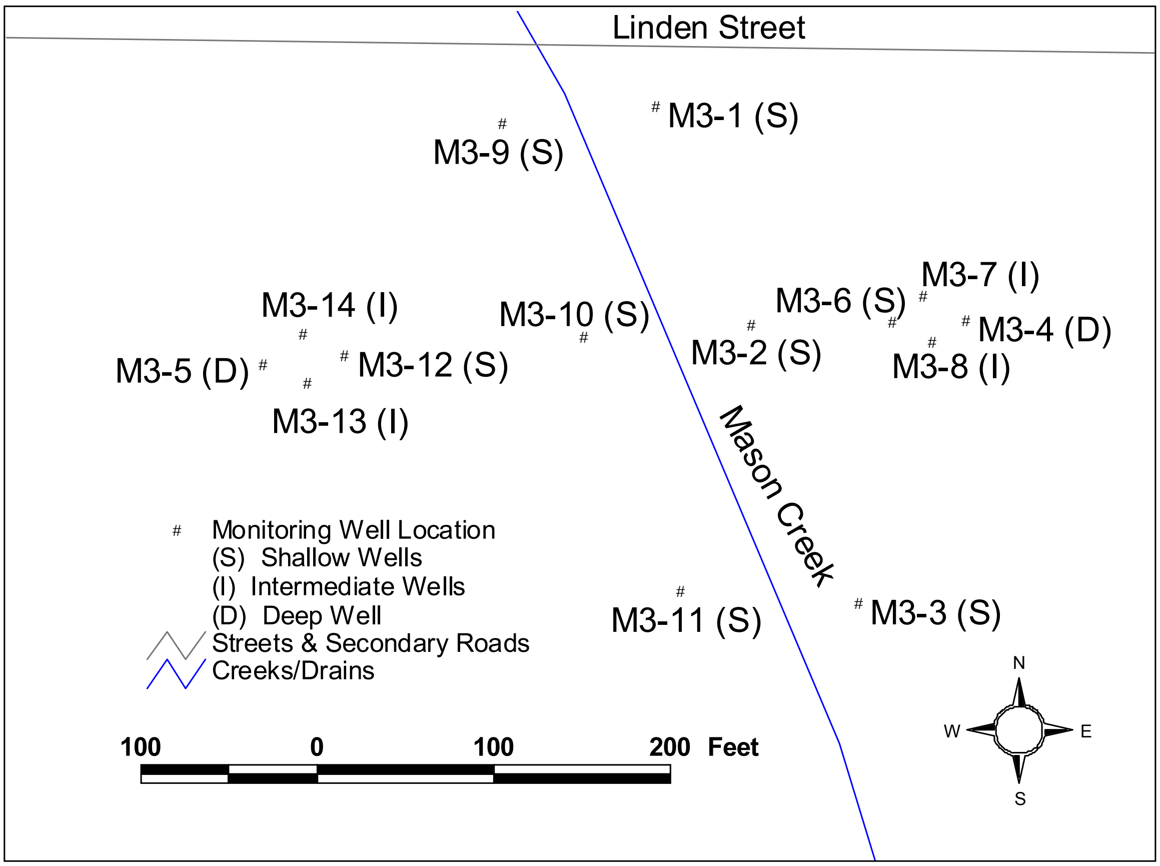


Figure 9. Monitoring well locations at site M-3.

Drain flow measurements were started in January 2001 and conducted on a monthly basis through the completion of the study. The flow measurements have a margin of error of approximately +/- 5%. The flow measurement data is listed in Appendix B.

Slug tests were performed on three wells at site M-3 on January 8, 2002. A PVC pipe filled with sand was used as a slug. The change in water level was recorded by a Solinst® Levelogger that was connected to a laptop to instantaneously download the data.

Water Table

Monthly static water level data were used to create water table maps with the computer program Surfer™. January and July were chosen to display the water table surface for the wet (January) and dry (July) seasons (Figure 10). January also represents non-irrigation season while July represents irrigation season. Figure 10 shows the general ground water flow of the shallow aquifer is to the northwest. The direction of ground water flow is not greatly effected by the change in weather or irrigation, seen by the similarities of flow directions between the January and July maps. The direction of ground water flow through Mason Creek in combination with the high water table indicates ground water and surface water interaction. Mason Creek is recharged with shallow ground water for the majority of the year.

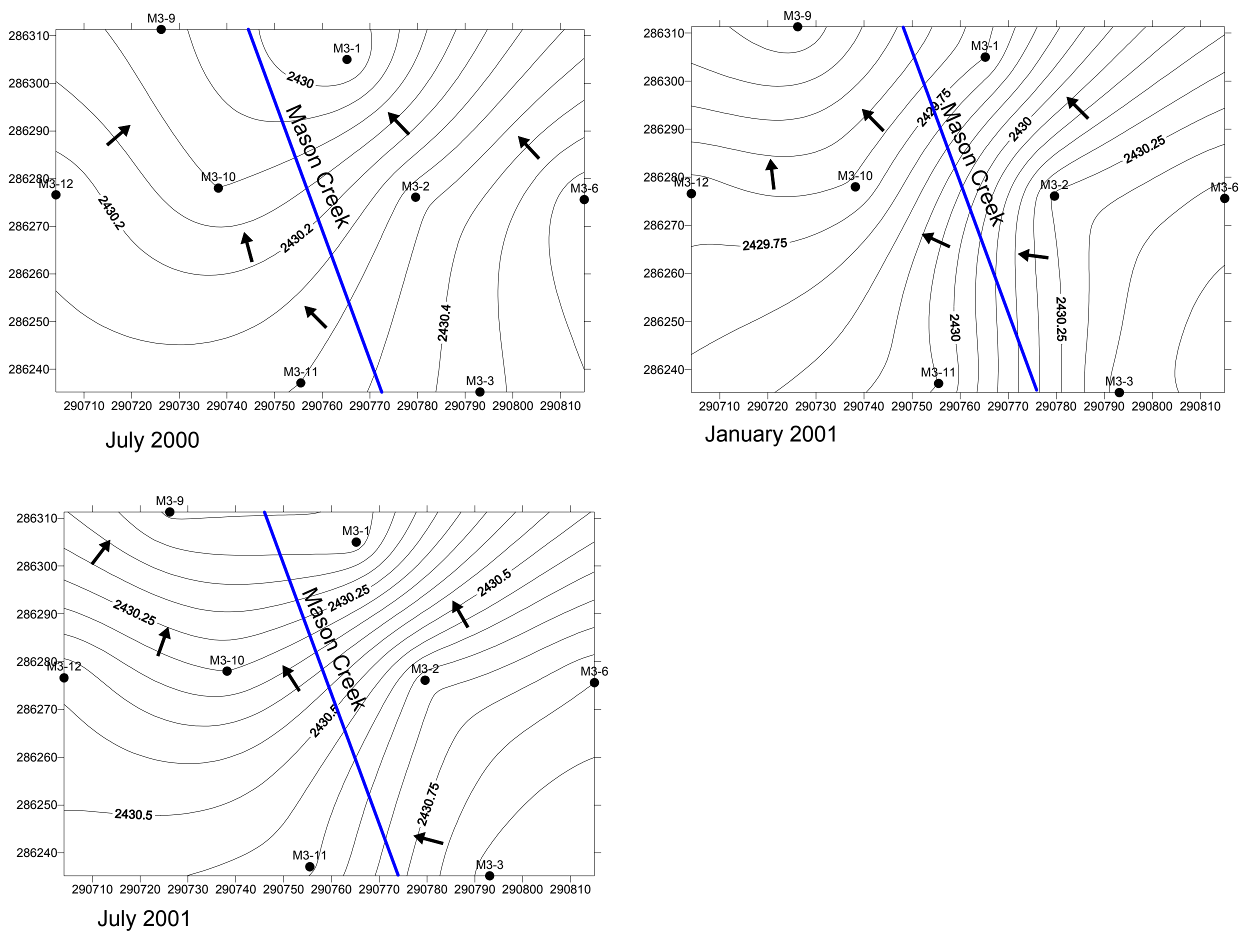


Figure 10. Water table map of M-3 shallow wells with direction of ground water flow.

M-3 Slug Tests

Slug tests were completed on several of the wells at site M-3 on January 8, 2002, including the shallow wells M3-10 and M3-12. A slug was made out of a PVC pipe filled with sand. The pipe was quickly lowered into the well via a rope while the change in water level was recorded by a Solinst® Levelogger that was connected to a laptop to instantaneously download the data.

Hvorslev slug test method was used to determine the hydraulic conductivity of the aquifer. The hydraulic conductivity values for these wells using the Hvorslev method ranged from 76 ft/day to 134 ft/day. The data falls within Fetter's (1994) hydraulic conductivity range for unconsolidated sands and gravels of 28 ft/day to 2835 ft/day. The hydraulic conductivity values were then used to estimate the flow between the upstream and downstream measurement points for discharge (approximately 1070 feet apart). The flow values ranged between 15,126 ft^3/day to 26,669 ft^3/day.

M-3 Stream Measurements

Discharge measurements were taken nine times during 2001. Discharge measurements at the upstream and downstream sites at M-3 were effected during the irrigation season by excessive aquatic plant growth. The actual discharge rate was probably somewhat higher than the measured discharge rate during the irrigation season because the accuracy of some discharge measurements were skewed by excessive plant growth. The discharge at the M-3 upstream site ranged from a low of 15.9 CFS during June 2001 to a high of 53.85 CFS during October 2001. The discharge at the M-3 downstream site ranged from a low of 11.07 CFS during August 2001 to a high of 56.2 CFS during April 2001. Upstream and downstream discharge measurements were used to calculate gains and losses of water to and from Mason Creek at site M-3. January through May were gaining periods of Mason Creek, while June through November were losing periods of Mason Creek at M-3. The flow measurement data are included in Appendix B. The locations of the discharge measurements are shown in Figure 11.

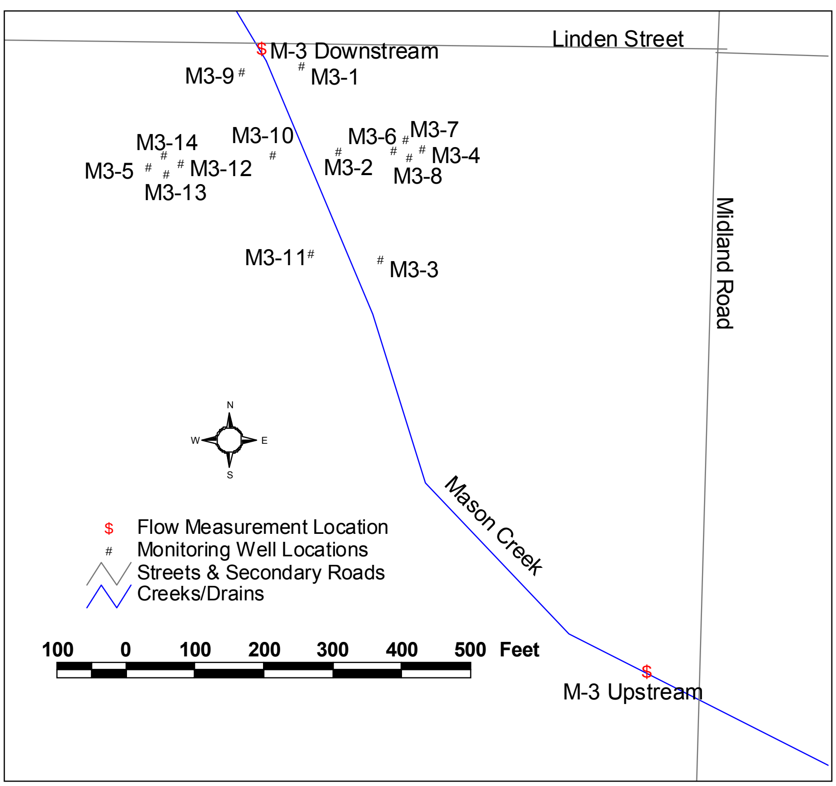


Figure 11. Map of M-3 flow measurement locations.

Water Quality and Surface Water and Ground Water Interactions

Site M-1

Overview

Ground water and surface water samples were collected monthly by ISDA and analyzed by Analytical Sciences Laboratory, Boise, Idaho. Ground water elevation measurements and field parameters were also collected monthly during the time of water sample collection. Physical and chemical data are listed in Appendix A.

Three soil samples were taken at site M-1 on May 29, 2001. The samples were collected using a two-inch auger. Samples were collected at depths of 0.5, 1, 2, 3, and 4 feet. The samples were taken to Western Labs in Parma, Idaho and analyzed for soluble salts, NO_3-N, phosphorous, and potassium. Sample results are listed in Appendix C. Three additional samples were planned for the fields east of soil samples M1-S1 and M1-S3 and the field south of soil sample M1-S1. However, permission was not secured from the landowners and the sample sites were dropped.

Nitrogen isotope testing of select wells was completed in December 2000 to help determine potential sources of contaminants entering ground water. The results are listed in Appendix D.

M-1 Ground Water Nitrate-Nitrogen

Nitrate-nitrogen concentrations of the shallow wells (less than 25 feet deep) at site M-1 ranged from a non detect (<0.02 mg/L) to 12.9 mg/L at M-1. Average concentrations were calculated for each monthly sampling event as seen in Figure 12.

For shallow wells at M-1, the highest monthly average NO_3-N concentration was 5.72 mg/L during the March 26, 2001 and April 20, 2001 sampling events. The lowest monthly average NO_3-N concentration for shallow wells was 3.74 mg/L during the June 18, 2001 sampling event. The average NO_3-N concentration for shallow wells for all sampling events was 4.65 mg/L. Overall, NO_3-N concentrations in the shallow wells were highest during non-irrigation season months from October to April and lowest during irrigation season months from April to October (Figure 12).

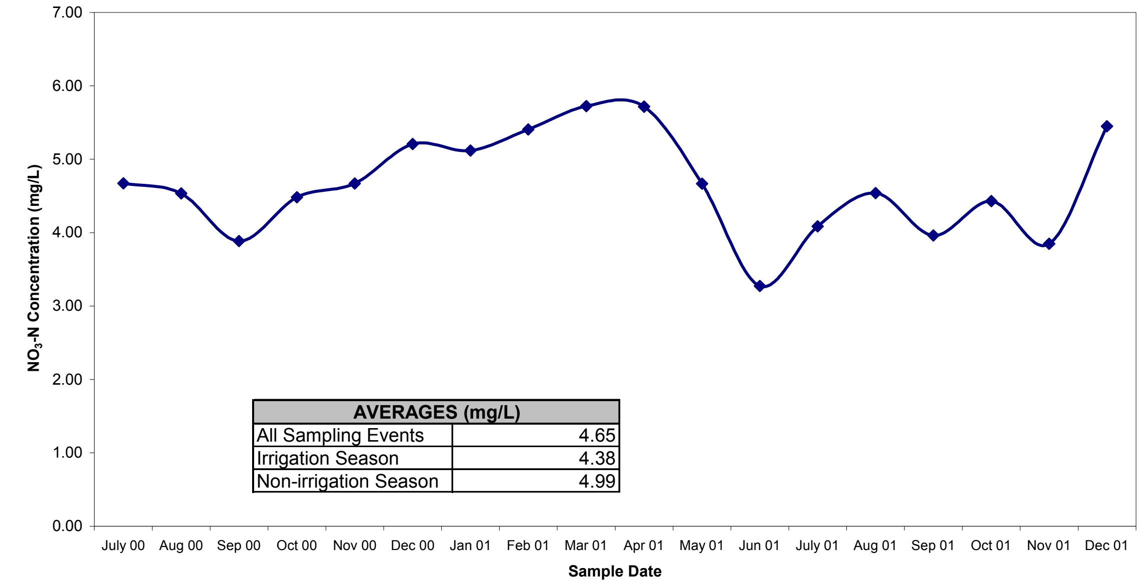


Figure 12. Time series plot of monthly averages for shallow well nitrate-nitrogen concentrations (mg/L) at M-1.

Nitrate-nitrogen concentrations of the intermediate wells (25 - 40 feet) ranged from 2.69 to 11.6 mg/L (Figure 13). Average concentrations were calculated for each individual intermediate well (Figure 13). Averages of all four intermediate wells were not calculated because each well was drilled to a different depth. The different depths do not represent one area of the aquifer; instead the intermediate wells sample different layers of the deeper local aquifer. The shallowest intermediate well (M1-5, 27 feet) generally showed the highest NO_3-N over the period of the study. The deepest intermediate well (M1-10, 39 feet) generally showed the lowest NO_3-N concentration over the period of the study.

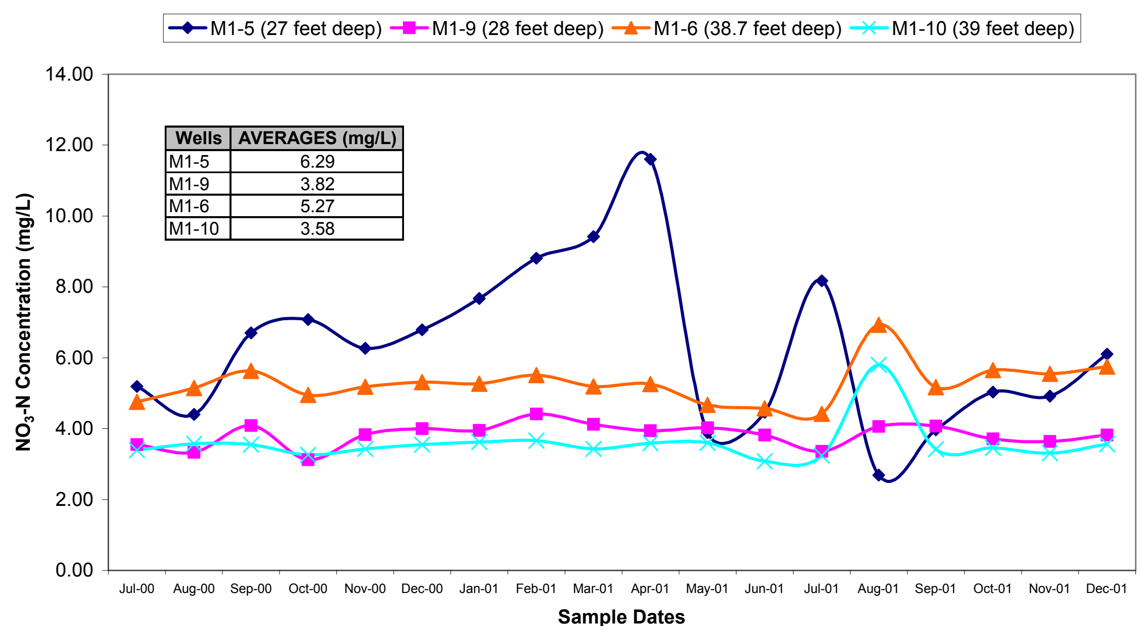


Figure 13. Time series plot of nitrate-nitrogen concentrations (mg/L) from intermediate wells at site M-1.

Site M-1 had only one deep well (117 feet). The highest NO_3-N concentration of the M-1 deep well was 0.52 mg/L, which was detected during the January 23, 2001 sampling event. The lowest NO_3-N concentration was a non-detect (<0.02 mg/L), which was recorded during the June 18, 2001 event. The average NO_3-N concentration for the deep well for all sampling events was 0.41 mg/L.

The shallow wells have an average NO_3-N value that is significantly greater than the deep well NO_3-N concentration. The shallow aquifer is unconfined and is unprotected from contaminant sources, while the deeper aquifer is protected from potential contaminant sources by the clay layer seen in the geologic cross section (Figure 4). The data also indicates that NO_3-N minimally impacts the deeper ground water systems. There is no direct relationship between the shallow and local intermediate aquifer. As seen in Table 1, two intermediate wells (M1-5 and M1-6) have higher average NO_3-N concentrations than the shallow wells. However, this appears be a function of the location of the wells. M1-5 and M1-6 are located on the north side of Mason Creek, which is downgradient from an active field. M1-5 and M1-6 are located next to the shallow well M1-4, which consistently had the highest NO_3-N concentration.

Table 1. Data summary table for M-1 ground water nitrate-nitrogen concentrations.

Well Type	Depth of well (feet)	Well(s)	NO_3-N Average (mg/L)
Shallow Wells	19-25	All Shallow Wells	4.65
Intermediate Wells	27	M1-5	6.29
	28	M1-9	3.82
	38.7	M1-6	5.27
	39	M1-10	3.58
Deep Well	117	M1-13	0.41

Contour maps were made of the site using NO_3-N concentrations of the shallow wells. The maps were produced in the computer program Surfer™ using ordinary kriging interpolation method. A default linear variogram fit by the program was used for the kriging covariance inputs. A selection of the maps can be seen in Figure 14. January, April, August, and November of 2000 and 2001 were chosen to evaluate different seasons in the agricultural year. The maps show that areas of high NO_3-N concentration are very similar from August 2000 through January 2001. During these months the areas of high NO_3-N concentrations were located north of Mason Creek, with some high concentrations located south of Mason Creek at M1-12. During the April 2001 sampling event M1-12 had the highest NO_3-N concentration. Generally, the highest NO_3-N values were located in the northeast section of the field down gradient from an active farm field. NO_3-N concentrations were generally lower on the south side of the site away from nearby farm fields.

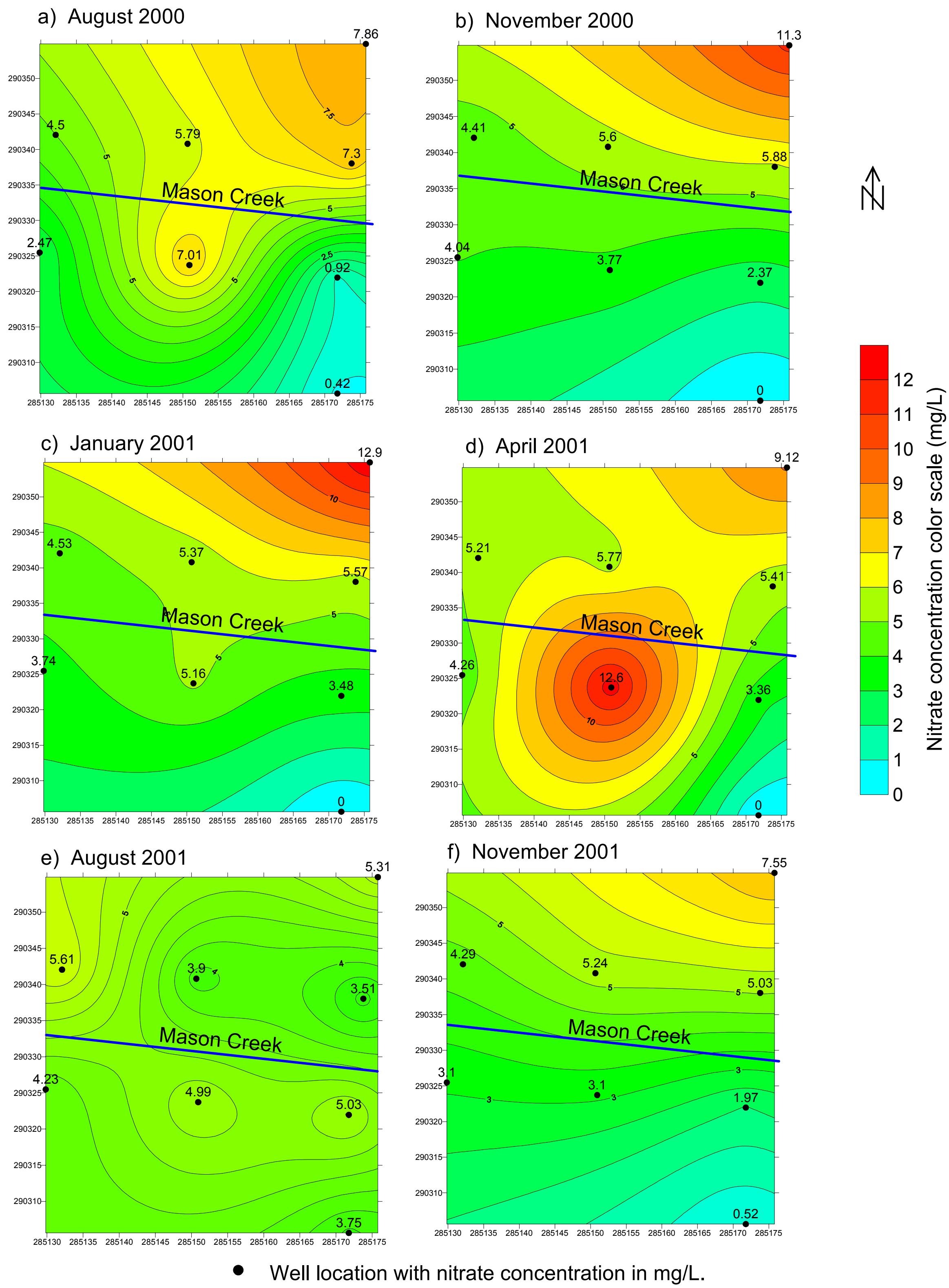


Figure 14. Contour map of nitrate-nitrogen concentrations of M-1 shallow wells.

M-1 Surface Water Nitrate-Nitrogen

A surface water sample was collected from Mason Creek every month during the study. The highest NO_3-N concentration was 5.31 mg/L, which was collected on October 25, 2000. The lowest NO_3-N concentration was 0.3 mg/L, collected on August 27, 2001. The average NO_3-N concentration of all 17 samples was 3.58 mg/L. Average NO_3-N concentrations were calculated for the irrigation season (mid April to mid October) and for the non-irrigation season (late October to early April). The irrigation season average NO_3-N concentration was 3.35 mg/L and was calculated from 10 samples. The non-irrigation season average NO_3-N concentration was 3.88 mg/L, which was calculated from eight samples.

The daily load of NO_3-N was calculated using instantaneous discharge and associated concentration of NO_3-N. Daily NO_3-N loads ranged from 132 to 1819 pounds/day. The average NO_3-N load for all sampling events was 1251 pounds/day. The irrigation season average NO_3-N load was 1169 pounds/day, calculated from six discharge measurements, while the non-irrigation season average was 1414 pounds/day, calculated from three discharge measurements.

M-1 Ground Water Orthophosphorous

Orthophosphorous concentrations of the shallow wells ranged from <0.05 to 1.14 mg/L at M-1. Average concentrations were calculated for each monthly sampling event for the shallow wells and plotted in a time series graph (Figure 15). For shallow wells at M-1, the highest monthly average orthophosphorous concentration was 0.41 mg/L during the July 12, 2000 sampling event. The lowest monthly average orthophosphorous concentration for shallow wells was 0.19 mg/L during the August 27, 2001 sampling event. The average orthophosphorous concentration for shallow wells for all sampling events was 0.33 mg/L.

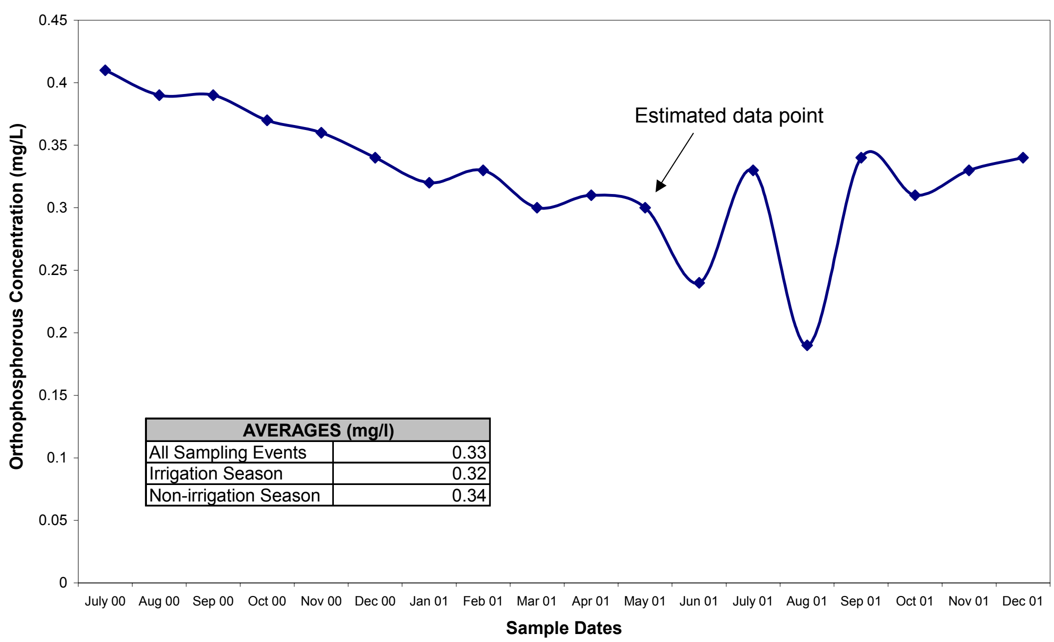


Figure 15. Time series plot of monthly averages for shallow well orthophosphorous concentrations at site M-1.

Orthophosphorous concentrations of the intermediate wells (25 to 40 feet) ranged from a non detect (<0.02 mg/L) to 0.65 mg/L at M-1. Figure 16 is a time series plot of orthophosphorous concentrations for each of the four intermediate wells. The plot shows two spikes in orthophosphorous concentration during August 2001 in wells M1-5 and M1-6. These wells are located near an active field, which could have caused the large spike in orthophosphorous concentration. The spike occurs in August, which is near the start of the irrigation season. The flood irrigation potentially leached orthophosphorous into the ground water, which eventually was detected in the wells M1-5 and M1-6, near the agricultural field. Average concentrations were calculated for each individual well (Figure 16). Average concentrations were not calculated for all four intermediate wells because of the varying sampling depths.

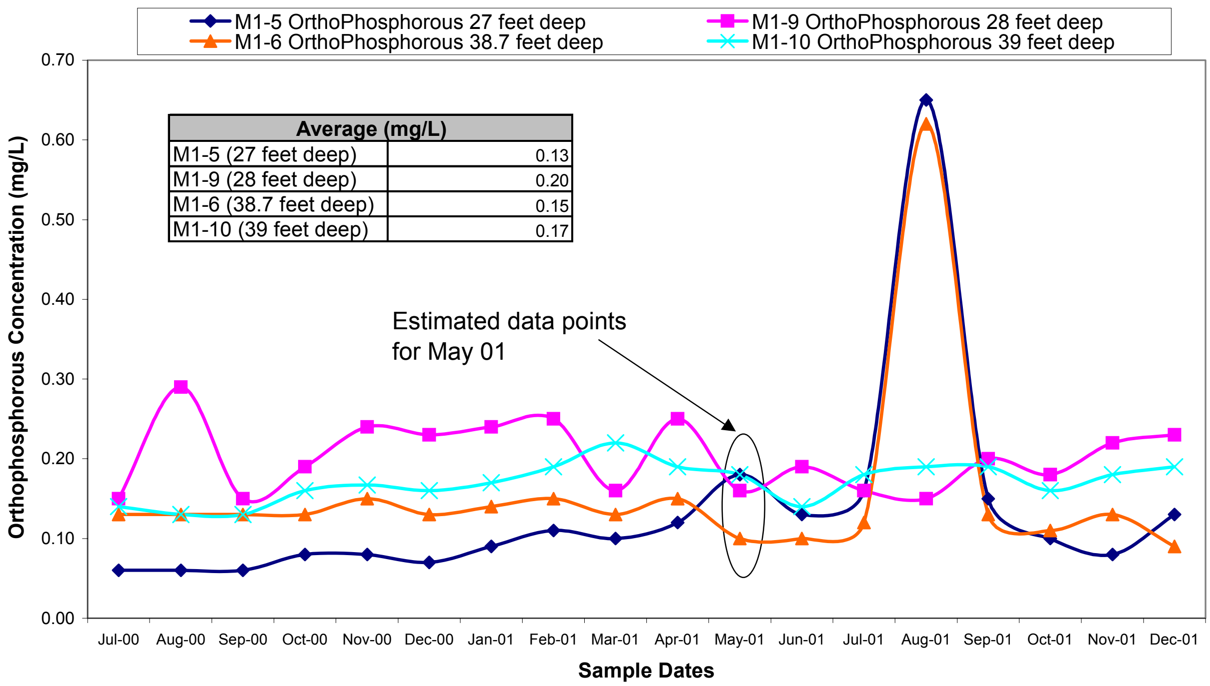


Figure 16. Time series plot of intermediate wells orthophosphorous concentrations (mg/L), site M-1.

The highest orthophosphorous concentration at the M-1 deep well was 0.13 mg/L, during the July 12, 2000 sampling event. The lowest orthophosphorous concentration was a non-detect (<0.02 mg/L), which was recorded during the following seven sampling events during 2001: June, July, August, September, October, November, and December. The average orthophosphorous concentration was 0.04 mg/L for the M-1 deep well.

As the depth below ground surface increases it appears that the concentration of orthophosphorous decreases (Table 2). The average orthophosphorous concentration for all shallow well samples is greater than all four of the individual intermediate wells. Each of the four individual intermediate well orthophosphorous concentrations is greater than the deep well average orthophosphorous concentration. There are some variations within the intermediate aquifer well data, but the overall data supports the trend that as the sample depth increases, the concentration of orthophosphorous decreases.

Table 2. Data summary for M-1 average orthophosphorous concentrations.

Well Type	Depth of well (feet)	Well(s)	Orthophosphorous Average (mg/L)
Shallow Wells	19-25	All Shallow Wells	0.33
Intermediate Wells	27	M1-5	0.13
	28	M1-9	0.20
	38.7	M1-6	0.15
	39	M1-10	0.17
Deep Wells	117	M1-13	0.04

Contour maps were made of the site using orthophosphorous concentrations of the shallow wells. The maps were produced in the computer program Surfer™ using ordinary kriging as the interpolation method. January, April, August, and November were chosen to represent different seasons in the agricultural year (Figure 17). The area of high orthophosphorous concentration is south of Mason Creek. It is interesting to note that geographic areas of high orthophosphorous concentrations do not correspond with geographic areas of high NO_3-N concentrations. In general, high NO_3-N concentrations are northeast of Mason Creek while high orthophosphorous concentrations are southwest of Mason Creek. A small man-made pond is located southwest of M1-11, which is the well that generally had the highest orthophosphorous concentrations. The pond could potentially leach orthophosphorous into the shallow ground water, causing the higher orthophosphorous concentrations in the shallow wells located south of Mason Creek. Another potential source of orthophosphorous are active fields located approximately 500 feet to the south of M1-11. The shallow ground water in the vicinity of the active fields generally flows to the north, towards Mason Creek and M1-11.

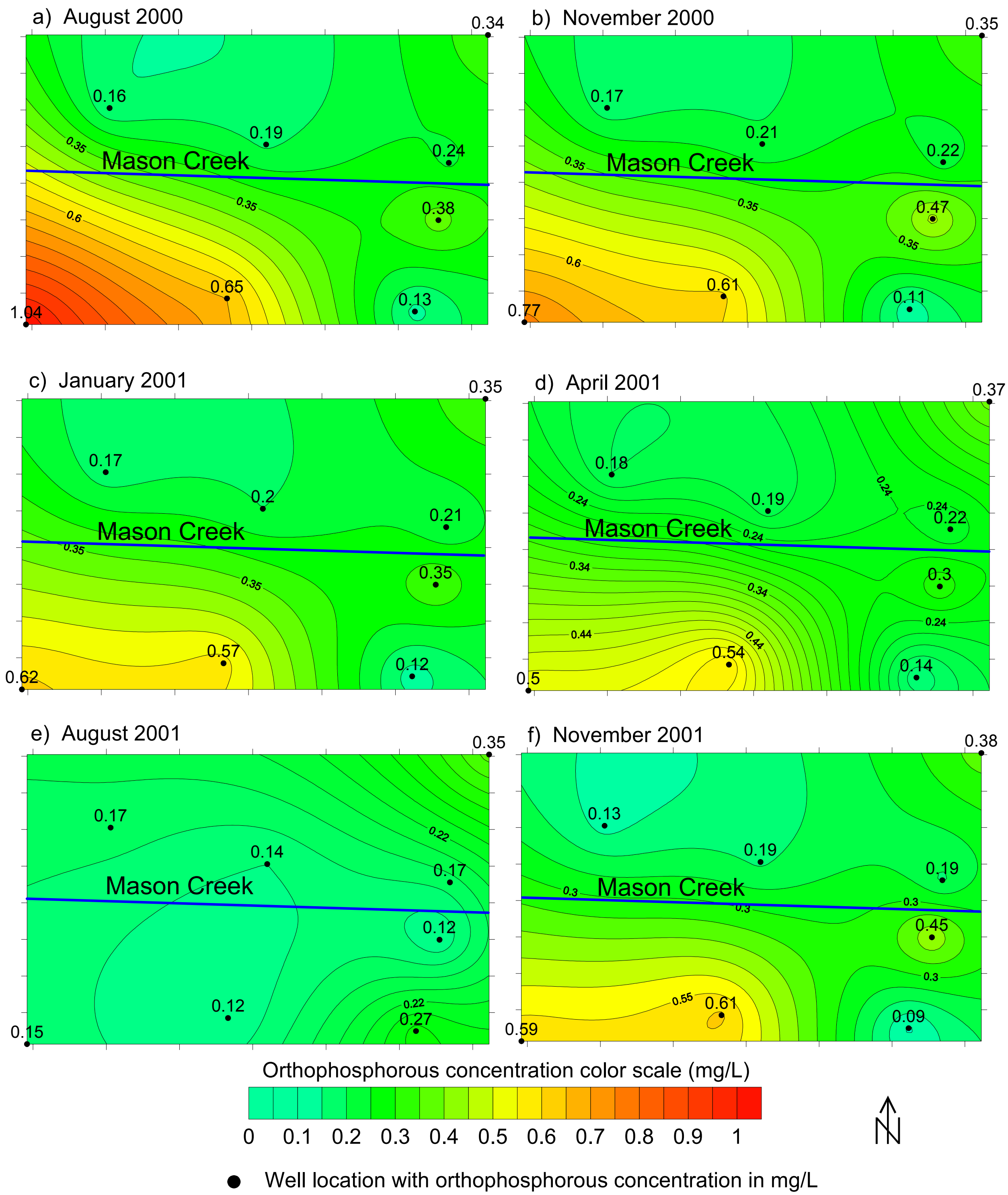


Figure 17. Orthophosphorous concentration map of shallow wells at M-1.

M-1 Surface Water Orthophosphorous

Monthly surface water samples also were analyzed for orthophosphorous concentrations. The highest orthophosphorous concentration was 0.32 mg/L, which was collected on July 12, 2000. The sample taken on December 20, 2000 had the lowest orthophosphorous concentration of 0.11 mg/L. The average orthophosphorous concentration of all 17 samples was 0.20 mg/L. Average orthophosphorous concentrations were calculated for the irrigation season (late May to October) and for the non-irrigation season (November to early May). The irrigation season average orthophosphorous concentration was 0.22 mg/L and was calculated from nine samples. The non-irrigation season average orthophosphorous concentration was 0.17 mg/L, which was calculated from eight samples.

The daily load of orthophosphorous was calculated using the instantaneous discharge and associated concentration of orthophosphorous for each sampling event. Daily orthophosphorous loads ranged from 45 to 178 pounds/day. The average orthophosphorous load for all sampling events was 74 pounds/day. The irrigation season average orthophosphorous load was 87 pounds/day, calculated from five discharge measurements; while the non-irrigation season average was 53 pounds/day, and calculated from three discharge measurements. The higher orthophosphorous concentration during the irrigation season could possibly be the result of an increase in orthophosphorous from irrigation water returns.

M-1 Soil Nitrate-Nitrogen Concentrations

Locations of M-1 soil samples are shown on Figure 18. Each soil sample location was sampled at various depths and analyzed for NO_3-N concentration. M-1 soil concentrations for NO_3-N are included in Appendix C.

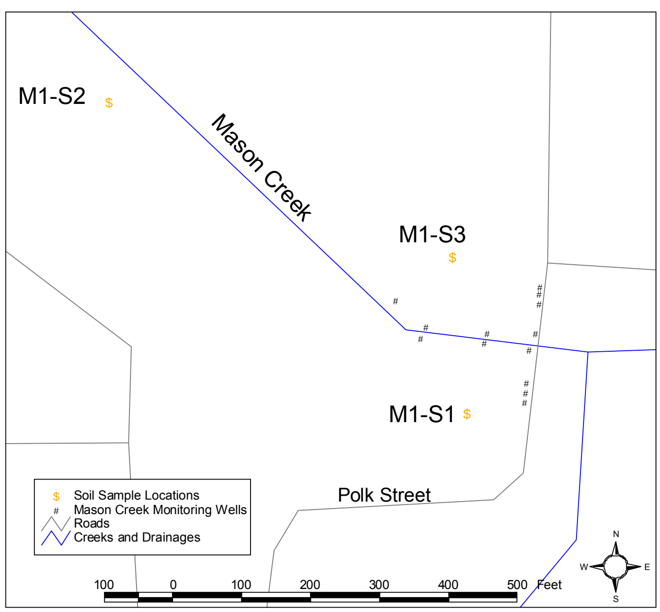


Figure 18. Soil sample locations at site M-1.

Only three locations at or near site M-1 were sampled due to difficulties in obtaining permission from landowners. The small number of data points at site M-1 makes geographic analysis difficult. However, it is possible to draw some general trends about NO_3-N concentrations at various soil depths. Generally, NO_3-N concentrations decreased at increased sample depth. This can be seen in the graphs of Figure 19, which plots NO_3-N concentration against sampling depth.

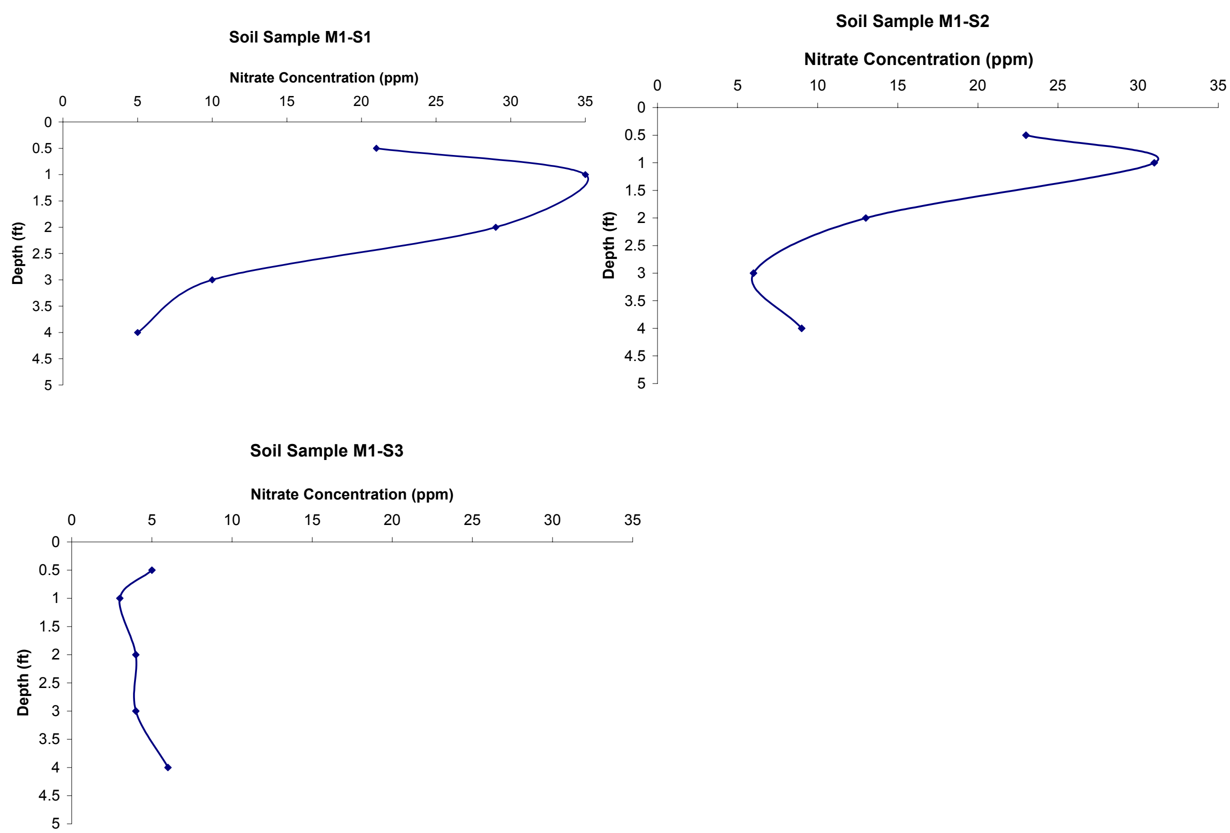


Figure 19. Soil samples M1-S1, M1-S2, and M1-S3 nitrate-nitrogen concentration versus sample depth at site M-1.

Average NO_3-N concentrations were calculated for each sampling depth. The average NO_3-N concentration at the 0.5-ft sample interval of the three locations was 16 parts per million (ppm). The average NO_3-N concentration of the one-ft sample depth increased to 23 ppm. The average NO_3-N concentration for the two-ft sample depth decreased to 15 ppm, and then decreased to 7 ppm for both the three and four-ft sampling intervals.

At two sample locations, M1-S1 and M1-S2, the NO_3-N concentration increased from the 0.5-ft sample depth to the one-ft sample depth and then decreased in NO_3-N concentration for the two and three-ft sampling intervals (Figure 19). M1-S2 increased slightly at the five-ft sampling interval, while M1-S1 continued to decrease. M1-S2 was located at the base of a bluff and was originally picked as a background sample because the location had never been farmed. However, after the sample was taken it was found that the location receives water run off from households located at the top of the bluff. The use of yard fertilizers may have leached into the soil at location of M1-S2, making it an inadequate background site. However, the samples did provide soil nutrient information about the location.

Soil sample M1-S3 displayed a different behavior, as seen in Figure 19. M1-S3 was taken in a horse pasture that receives little to no chemical applications. The NO_3-N concentration of M1-S3 is very low in comparison to the concentrations found at the other two sites. However, the NO_3-N concentration of M1-S3 increases with increasing sample depth. The NO_3-N concentration at the four-ft sampling depth is actually higher than the concentration at the 0.5-ft sampling depth, which is not observed in any other soil samples at site M-1.

The limited data points make a geographical analysis of NO_3-N concentration very difficult. Figure 20 indicates that the southwest side of Mason Creek generally has a higher NO_3-N concentration than the northeast side of the creek. The exception being the four-ft sampling depth, in which the soil sample from the north side of Mason Creek had a slightly higher NO_3-N value than the soil sample directly south.

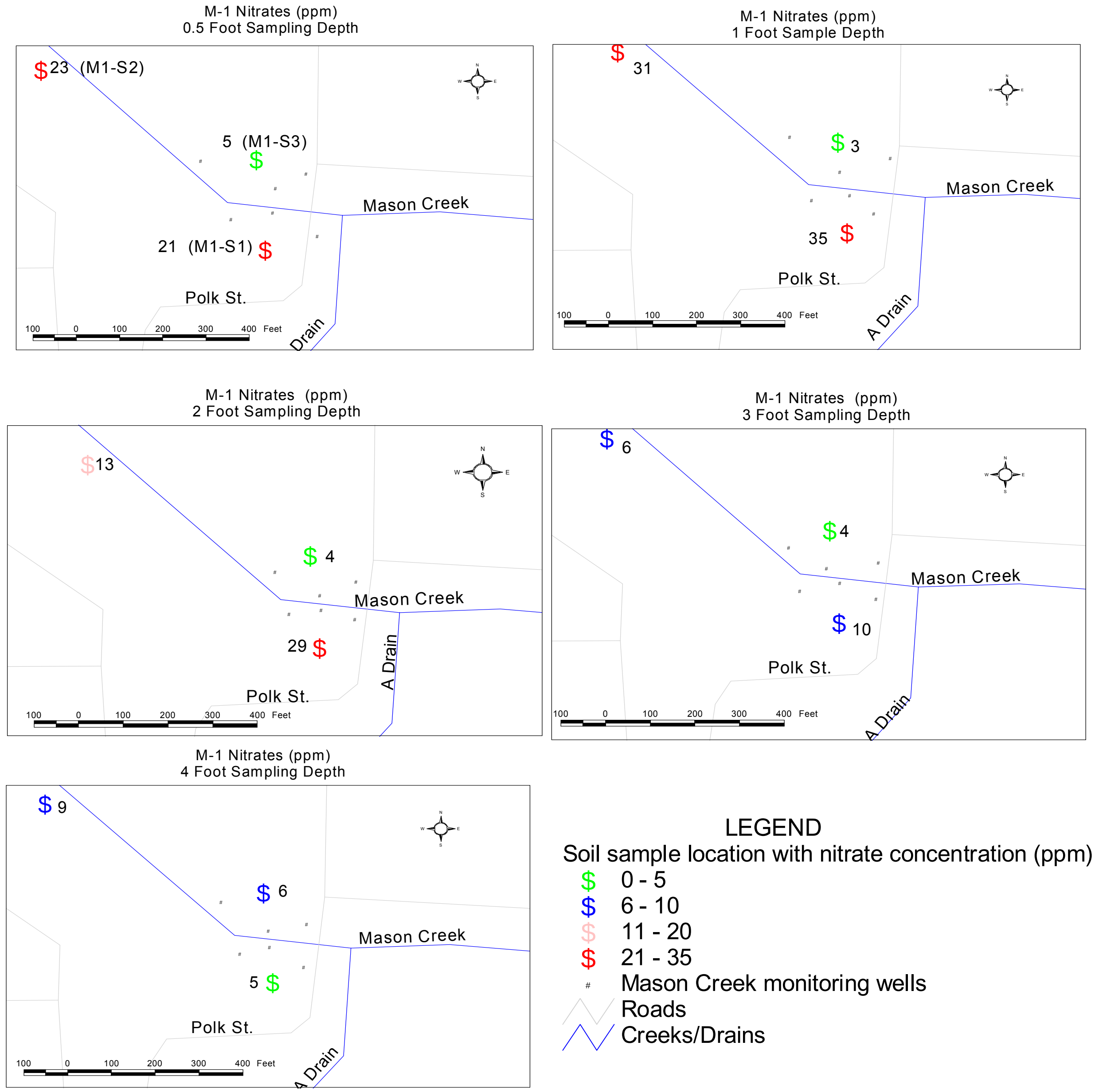


Figure 20. Soil nitrate-nitrogen concentration and geographic location at site M-1.

M-1 Soil Phosphorous Concentrations

Soil samples collected at M-1 were also analyzed for total phosphorous. The average phosphorous concentration for the 0.5-ft sampling depth was 14 ppm. The average phosphorous concentration increased at the one-ft sampling depth to 19 ppm. The two and three-ft sampling depth average phosphorous concentration decreased to 12 and 8 ppm, respectively. The four-ft sampling depth average phosphorous concentration increased to 10 ppm. This is the only situation in which the average concentration does not decrease with increasing sampling depth.

M1-S1 displays a general trend in which phosphorous concentration decreases with increasing depth as seen on Figure 21. Soil sample M3-S2 phosphorous concentration increased from the 0.5 to the one-ft sampling depths, then decreased at the two and three-ft depths, and increased again at the four-ft depth.

M1-S3 phosphorous concentration was very low in comparison to the other sample locations. However, the phosphorous concentration increased slightly with depth. The phosphorous concentration was the same for the 0.5-ft sampling interval as the four-ft sampling interval (5 ppm). M1-S3 was the only sampling location at M-1 in which the shallow sample (0.5 ft) has the same concentration as the deep sample (four-ft). This sample site is located within a horse pasture, which receives little to no chemical applications. The NO_3-N concentrations of M1-S3 follow the same trend as the phosphorous concentration; both concentrations increased with increasing depth.

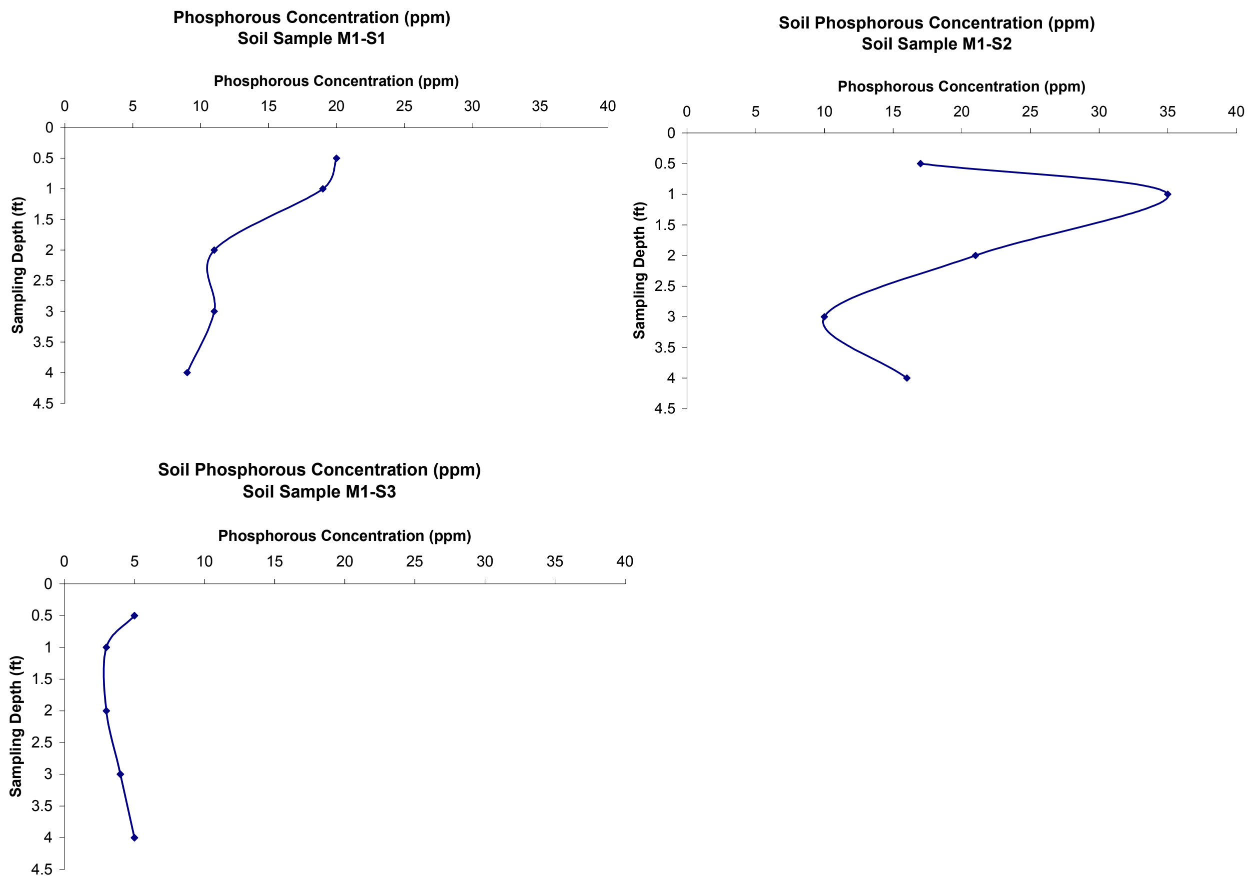


Figure 21. Soil phosphorous concentration versus sample depth at site M-1.

Figure 22 shows the various concentration gradients exhibited for each soil sampling site. At all sampling depths, the southwest side of Mason Creek has a higher phosphorous concentration than the northeast side of the creek. This equates with the general trend of the NO_3-N soil concentrations. Another correlation is that the ground water orthophosphorous and phosphorous concentrations were highest on the southwest side of Mason Creek.

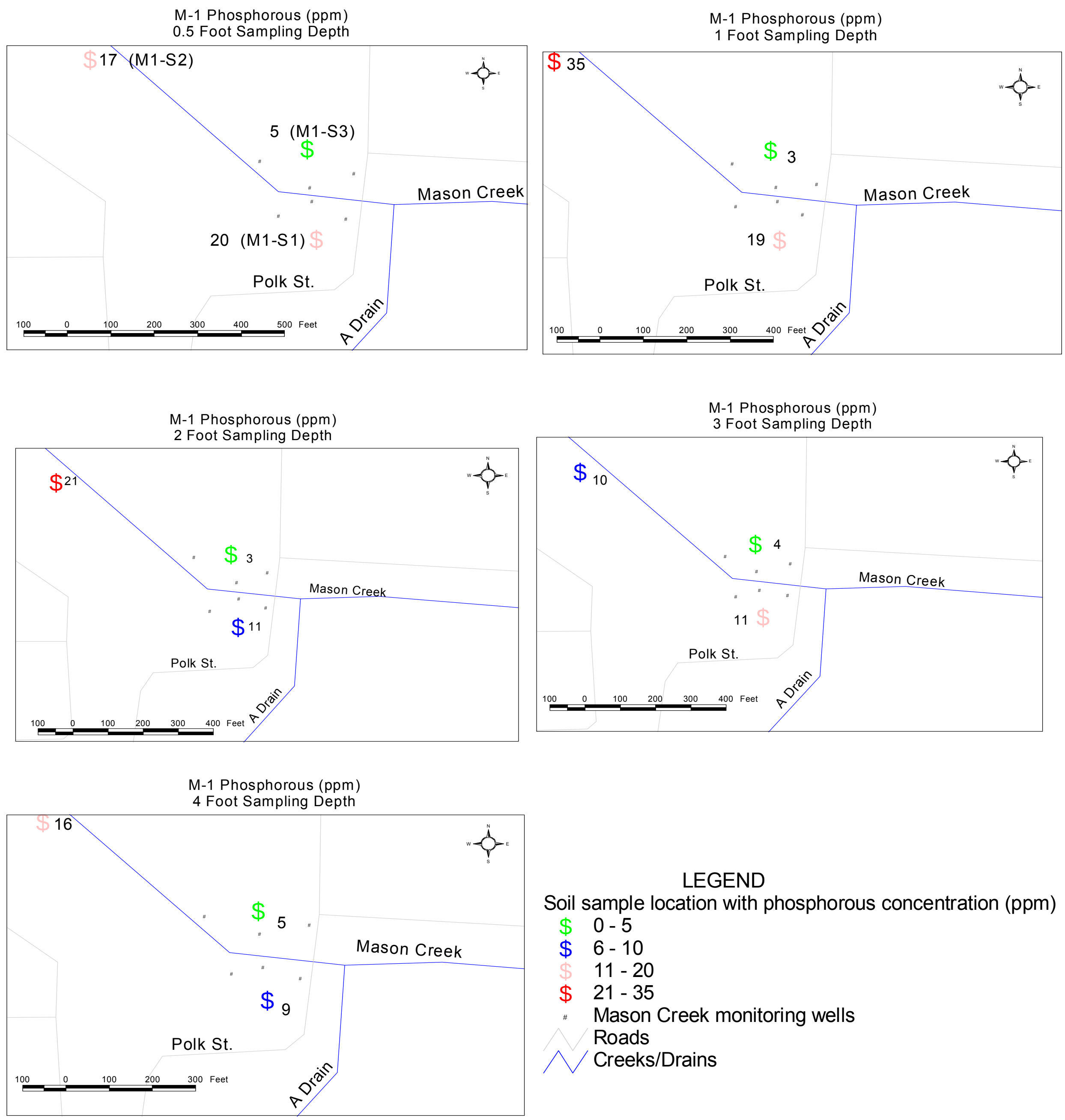


Figure 22. Soil phosphorous concentration and geographic location site M-1.

M-1 Regression Plots

Analytical data, over time, from ground water and surface water samples at site M-1 were used to complete a linear regression analysis. Prior to the analysis, a significance level of 0.1 was selected for a statistical F test. However, all plots passed a significance level of 0.05. Several different plots were created: 1) using all data points, 2) using irrigation season data, and 3) using non-irrigation season data. These different plots were further broken into two groups: 1) using raw data points and 2) using averages of the four shallow wells from both sides of Mason Creek from each sampling event (wells M1-1, M1-2, M1-3, and M1-4 were averaged together; and wells M1-7, M1-8, M1-11, and M1-12 were averaged together). The plots are included as Appendix F. A few bivariate relationships were observed based on the coefficient of determination (R^2) and F test findings. Most R^2 values were less than 0.70, but all F test findings met the significance level of 0.1. While the trend in not strong, there is a statistical relationship that is evident. As the ground water elevation rose, NO_3-N concentrations decreased. This is seen in all the regression plots for M-1, but is distinctive for the averaged non-irrigation season data, where the R^2 value was 0.7486 (Figure 23a). As ground water elevations rose, total phosphorous and orthophosphorous concentrations increased. Again, this correlation is most strongly seen in the averaged non-irrigation season data where the R^2 value was 0.86 for both plots (Figures 23b and 24). The irrigation season data also showed the same relationships between the nutrients and ground water elevation, however the R^2 values were lower, ranging from 0.2964 to 0.5758.

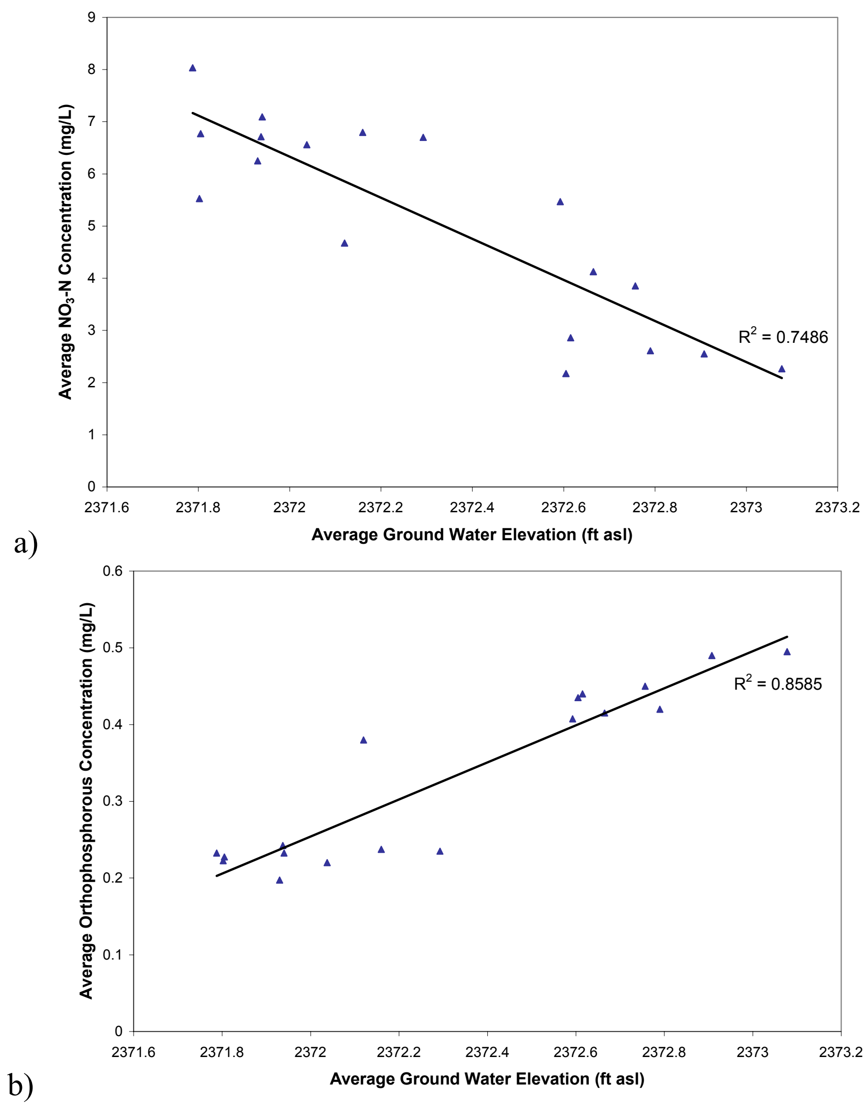


Figure 23. Regression plots for M-1 shallow wells non-irrigation season average ground water elevation versus a) average nitrate-nitrogen concentration and b) versus average orthophosphorous concentration.

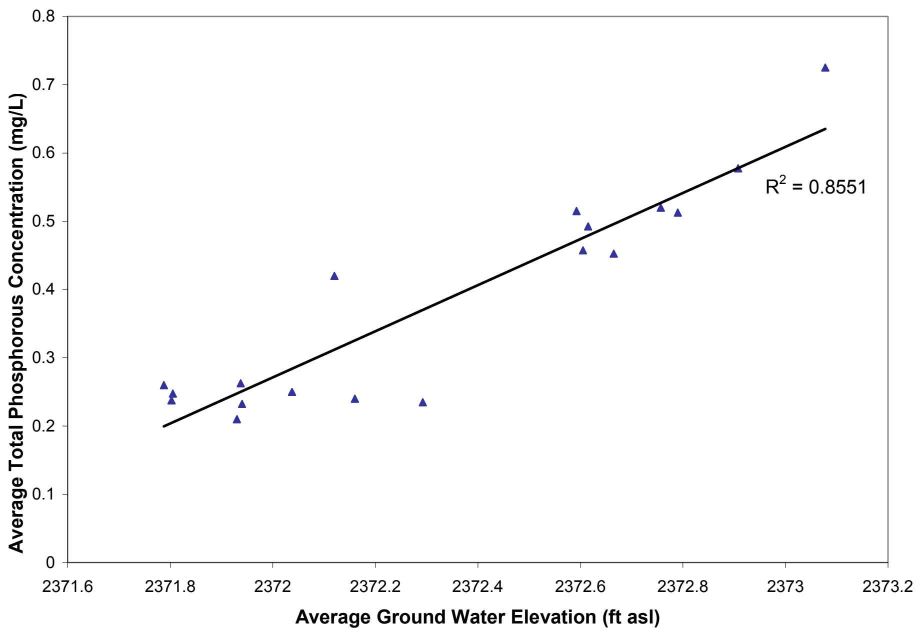


Figure 24. Regression plot for M-1 shallow wells non-irrigation season average ground water elevation versus average total phosphorous concentration.

M-1 Surface Water and Ground Water Interactions

Figure 25 shows a time series plot of surface water NO_3-N concentrations and shallow ground water average concentrations. The surface water NO_3-N concentrations are greater than the average shallow ground water concentrations during October and November of 2000 and 2001, which is the end of the irrigation season. This increase of NO_3-N concentration within the surface water could be a result of shallow ground water influence as site M-1 switches from a losing to a gaining section of Mason Creek (see Figure 26). The addition of the shallow ground water with high NO_3-N concentration into Mason Creek will increase the NO_3-N concentration within the drain.

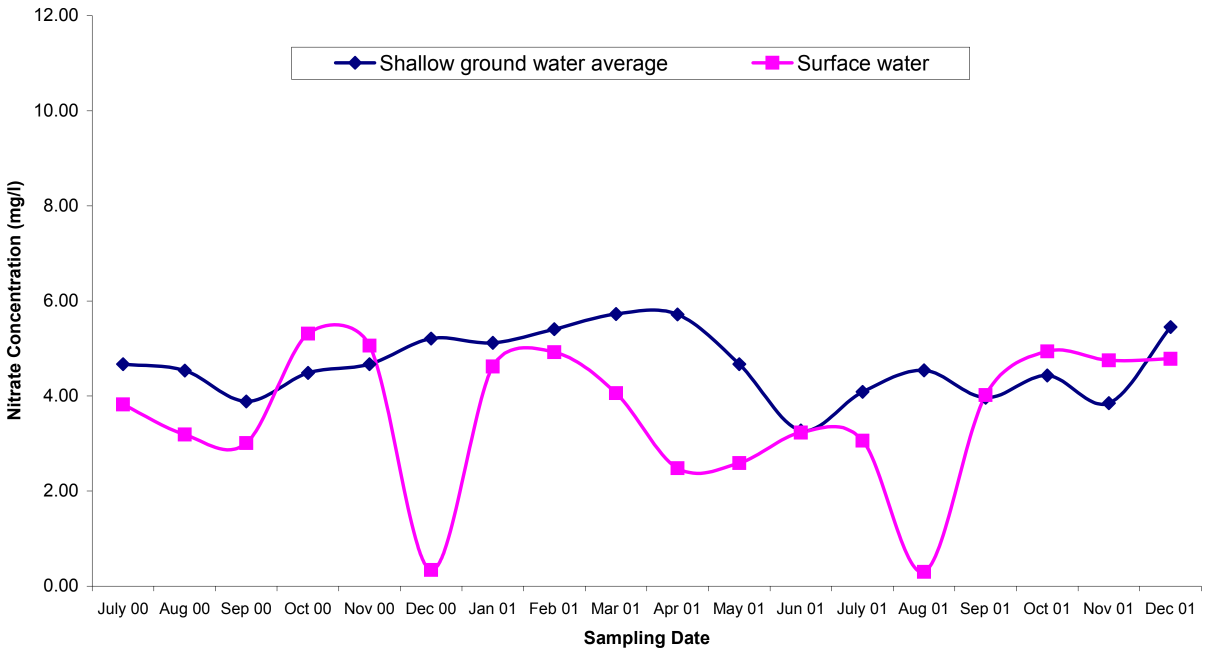


Figure 25. Time series plot of M-1 surface water and shallow ground water nitrate-nitrogen concentrations.

Ground water contribution of NO_3-N to Mason Creek was calculated by multiplying the net gain of discharge in Mason Creek at M-1 by the average shallow ground water NO_3-N concentration for each month. During the months when M-1 was a losing portion of Mason Creek, the net loss of NO_3-N to the ground water was calculated by multiplying the net loss of discharge from Mason Creek by the surface water NO_3-N concentration. Figure 26 shows the NO_3-N load in pounds per month that either ground water contributed to Mason Creek (positive y values) or that Mason Creek contributed to the ground water (negative y values) for the nine months in 2001 that flow measurements were taken at the site. During the nine months in which the loads were calculated, Mason Creek gained approximately a net total of 17,076 pounds of NO_3-N from the ground water at M-1. This accounts for 2% of the yearly NO_3-N load that Mullins (1998) calculated Mason Creek contributed to the Boise River.

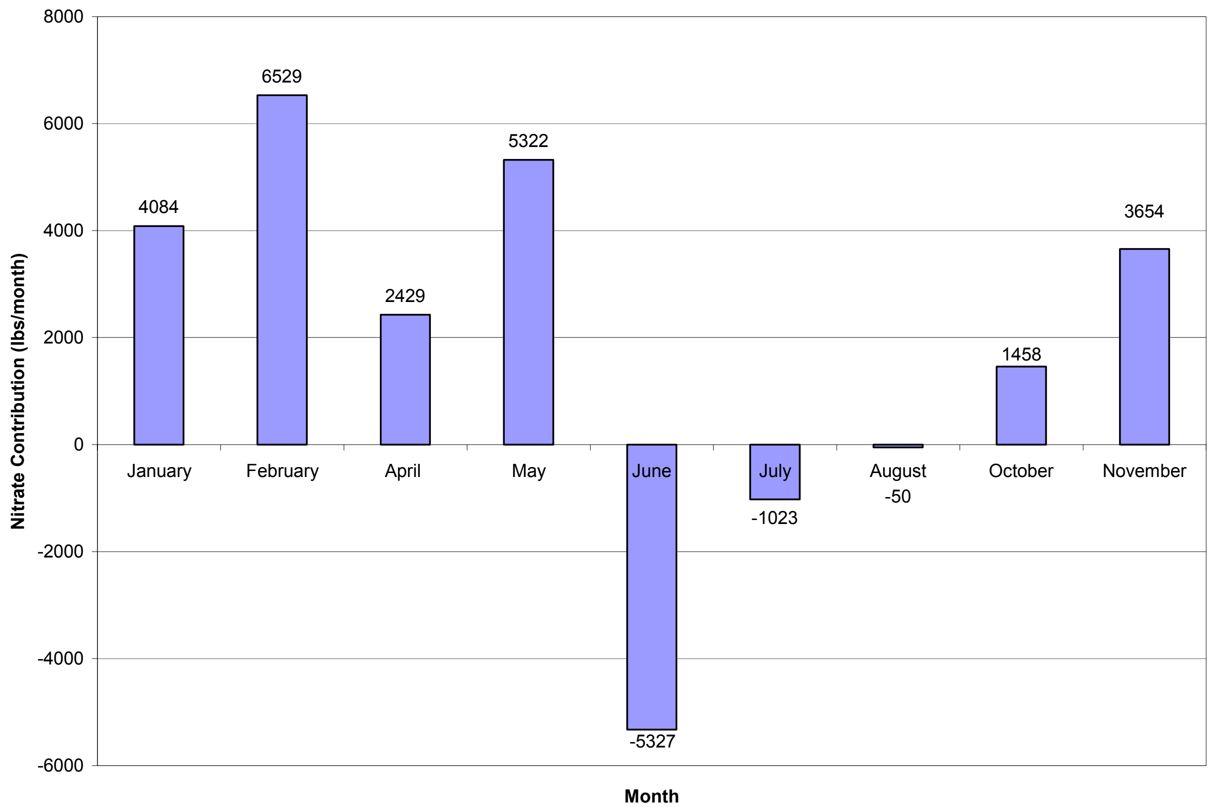


Figure 26. Ground water nitrate-nitrogen contribution to Mason Creek at site M-1 in 2001.

For the six months that Mason Creek gained shallow ground water (Figure 26), the average daily contribution of NO_3-N to Mason Creek from the ground water at site M-1 was 130 pounds/day. The average daily contribution was used to determine the percentage of instantaneous NO_3-N load at site M-1 that was contributed by ground water. This was done by dividing the instantaneous load at site M-1, calculated in various studies, by 130 pounds/day. The results are shown in Table 3. The percentage of instantaneous NO_3-N load at site M-1 contributed by ground water was fairly consistent for each study.

Table 3. Nitrate-nitrogen load contributed to M-1 by ground water.

Study	Calculated instantaneous NO_3-N load of Mason Creek, Site M-1	Percentage of instantaneous NO_3-N load contributed by ground water, Site M-1
Mullins, 1998	2,260 lbs/day	8%
ISDA 1999-2000	1,414 lbs/day	9%
ISDA 319 study	1,251 lbs/day	10%

Ground water contributions of orthophosphorous to Mason Creek at M-1 was calculated using the same methods as calculating the NO_3-N ground water contribution. Figure 27 shows the orthophosphorous load in pounds per month that ground water contributed to Mason Creek (positive y values) or that Mason Creek contributed to the ground water (negative y values) for the eight months that the flow measurements were taken. During the eight months in 2001 in which the loads were calculated, Mason Creek gained approximately a net total of 650 pounds of orthophosphorous from the ground water at M-1.

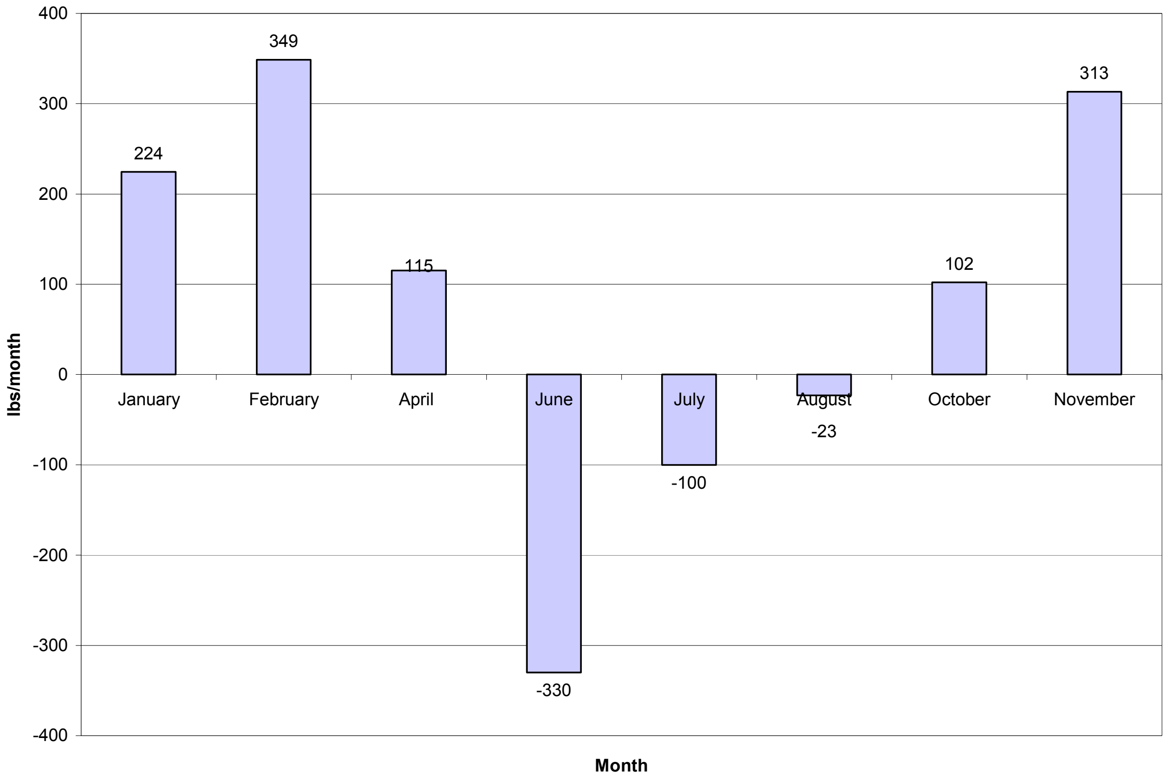


Figure 27. Ground water orthophosphorous contribution to Mason Creek at site M-1 in 2001.

For the five months that Mason Creek gained water from the shallow aquifer (Figure 27) the average daily contribution of orthophosphorous to Mason Creek from ground water at site M-1 was 7.4 pounds/day. The average daily contribution was used to determine the percentage of instantaneous orthophosphorous load at site M-1 that was contributed by ground water. This was done by dividing the instantaneous load at site M-1, calculated in various studies, by 7.4 pounds/day. The results are shown in Table 4. The percentage of instantaneous orthophosphorous load at site M-1 contributed by ground water was similar for each study.

Table 4. Orthophosphorous load contributed to M-1 by ground water.

Study	Calculated instantaneous orthophosphorous load of Mason Creek, Site M-1	Percentage of instantaneous orthophosphorous load contributed by ground water, Site M-1
Mullins, 1998	63 lbs/day	12%
ISDA 1998-1999	66 lbs/day	11%
319 study	74 lbs/day	10%

M-1 Nitrogen Isotope Testing

Samples were collected at all wells for nitrogen isotope analysis in December 2000. Nitrogen isotope is the measurement of the ratio of common nitrogen isotope ^{14}N to its less abundant counterpart ^{15}N relative to a known standard and is denoted as $\delta^{15}N$. The reason for the $\delta^{15}N$ analysis is to aid in determining the sources of nitrogen. Common sources of nitrogen in the ground water are applied commercial fertilizers, animal or human waste, precipitation, and organic nitrogen within the soil. Each of these sources has a distinguishable $\delta^{15}N$ signature. Figure 28 shows ranges of $\delta^{15}N$ determined through numerous research studies. The graph displays the number of samples tested (y-axis) as compared to $\delta^{15}N$ results (x-axis) for various nitrogen sources. Typical $\delta^{15}N$ ranges for fertilizer is –4 to +4, while typical waste sources have ranges greater than 10, as seen on Figure 28 (Seiler, 1996). $\delta^{15}N$ values between 4 and 10 are generally believed to indicate an organic or mixed source.

Use of nitrogen isotopes as the sole means to determine NO_3-N sources should be done with great care. $\delta^{15}N$ values in ground water can be complicated by several reactions (e.g., ammonia volatilization, nitrification, denitrification, plant uptake, etc.) that can modify the $\delta^{15}N$ values (Kendall and McDonnel, 1998). Furthermore, mixing of sources along shallow flowpaths makes determination of sources and extent of denitrificaiton very difficult (Kendall and McDonnel, 1998).

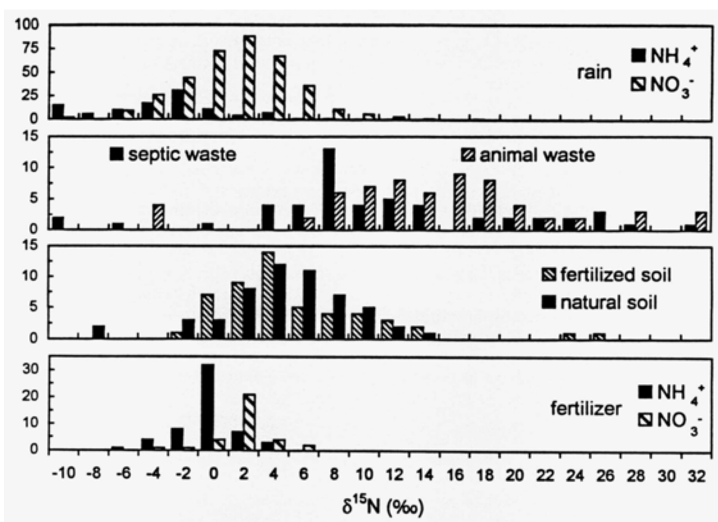


Figure 28. Ranges of δ Nitrogen-15 Isotope found in the hydrosphere based on a number of nitrogen isotope studies (after Kendall and McDonnel, 1998).

Results of the $\delta^{15}N$ testing in 2000 returned values that ranged from 7.38 – 63.11$^0/_{00}$ (Table 5). Nine wells tested above 10$^0/_{00}$, which is in the animal or human waste source range, five of those wells are located within a horse pasture as well as down gradient from a small confined animal feeding operation and land application sites. However, the higher values detected at wells M1-1, M1-4, M1-5, and M1-10 could also be the result of denitrification of commercial fertilizers or other sources. A denitrification evaluation was beyond the scope of this study. Two wells tested between 5 - 10$^0/_{00}$, suggesting an organic or mixed source of NO_3-N, one located in the pasture and the other in the grass yard. The surface water sample taken had a concentration of $9^0/_{00}$, also suggested an organic or mixed source of NO_3-N. No wells returned values that suggested a fertilizer source.

Table 5. 2000 Nitrogen-15 Isotope results for site M-1.

Well ID	Sample Date	N-15 ($^O/_{OO}$)
M1-1	Dec-00	21.29
M1-2	Dec-00	19.61
M1-3	Dec-00	10.66
M1-4	Dec-00	25.98
M1-5	Dec-00	20.64
M1-6	Dec-00	7.38
M1-7	Dec-00	18.08
M1-9	Dec-00	14.41
M1-10	Dec-00	63.11
M1-11	Dec-00	9.72
M1-12	Dec-00	10.12
M1-SW	Dec-00	9.00

Site M-3

Overview

Ground water and surface water samples were collected monthly by ISDA and analyzed by the Analytical Sciences Laboratory. Field parameters were also collected monthly during the time of water sample collection. Physical and chemical data are listed in Appendix A.

Ten soil samples were taken at site M-3 on May 23, 2001. The samples were collected using a two-inch auger. Samples were taken at each sample location at depths of 0.5, 1, 2, 3, 4, and 5 feet when possible. Two soil samples were taken in areas with high cobble content, which made drilling difficult. In these areas the deepest sample was taken at two feet to avoid bending or breaking the auger. The samples were taken to Western Labs in Parma, Idaho and analyzed for soluble salts, NO_3-N, phosphorous, and potassium. The soil sample results are listed in Appendix C.

Nitrogen isotope testing was completed in December 2000 to help determine potential sources of contaminants entering ground water. The results are listed in Appendix D.

M-3 Ground Water Nitrate-Nitrogen

Nitrate-nitrogen concentrations of the shallow wells (less than 25 feet deep) ranged from 1.45 to 24.5 mg/L. Average NO_3-N concentrations were calculated for each monthly sampling event and graphed as a time series plot (Figure 29). For shallow wells at M-3, the highest monthly average NO_3-N concentration for all sampling rounds was 11.46 mg/L during the July 18, 2001 sampling event. The lowest monthly average NO_3-N concentration for shallow wells was 7.73 mg/L during the July 20, 2000 sampling event. The average NO_3-N concentration for shallow wells for all sampling events was 9.25 mg/L.

The beginning of the 2001 irrigation season shows a significant increase in NO_3-N concentrations during May, June, and July. The field adjacent to the monitoring wells had previously been planted with alfalfa but was not farmed during 2000. The field was flood irrigated beginning May 2001 to revive the crop. The increase in NO_3-N values corresponding to the same time as flood irrigation is a strong indication that flood irrigation water leached NO_3-N into the shallow aquifer. Overall, NO_3-N concentrations show a steady increasing trend over the period of this study.

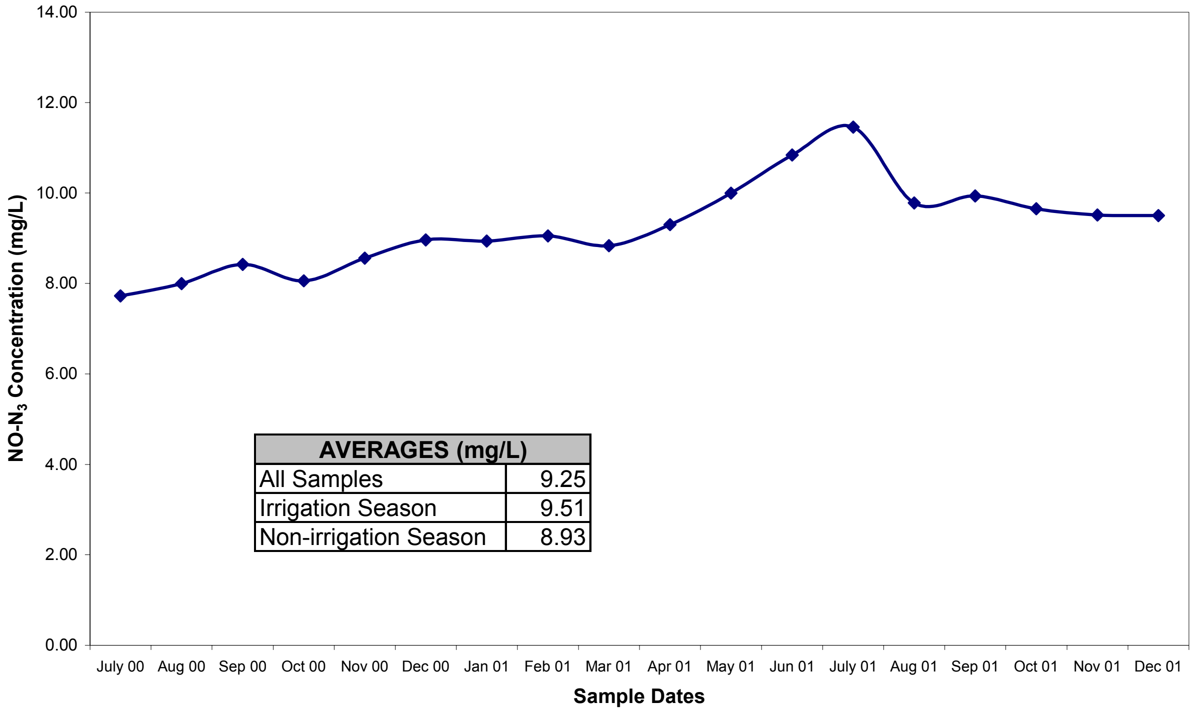


Figure 29. Time series plot of average nitrate-nitrogen concentrations for shallow wells at M-3.

Nitrate-nitrogen concentrations of the intermediate wells (25 to 55 feet) ranged from 0.80 to 15.7 mg/L at M-3. Figure 30 shows a time series plot of each the intermediate wells NO_3-N concentrations. Average concentrations were calculated for each individual well (Figure 30). Averages of all four intermediate wells were not calculated because each well was drilled to a different depth. The different depths do not represent one area of the aquifer; instead the intermediate wells sample different layers of the local intermediate aquifer. However, there does appear to be a spatial correlation between NO_3-N concentrations with higher levels appearing on the east side of the drain in wells M3-8 and M3-7. Also, the deeper intermediate wells per side (M3-14 and M3-8) show relatively higher NO_3-N than the shallower intermediate wells (Figure 30). There is a general increasing trend noticeable on the time series plot. The increasing NO_3-N concentration could be due to the irrigation of the agricultural fields surrounding the monitoring wells during the 2001 farming season. During the June 2001 sampling event, all of the intermediate well NO_3-N concentrations dropped, with M3-14 dropping significantly.

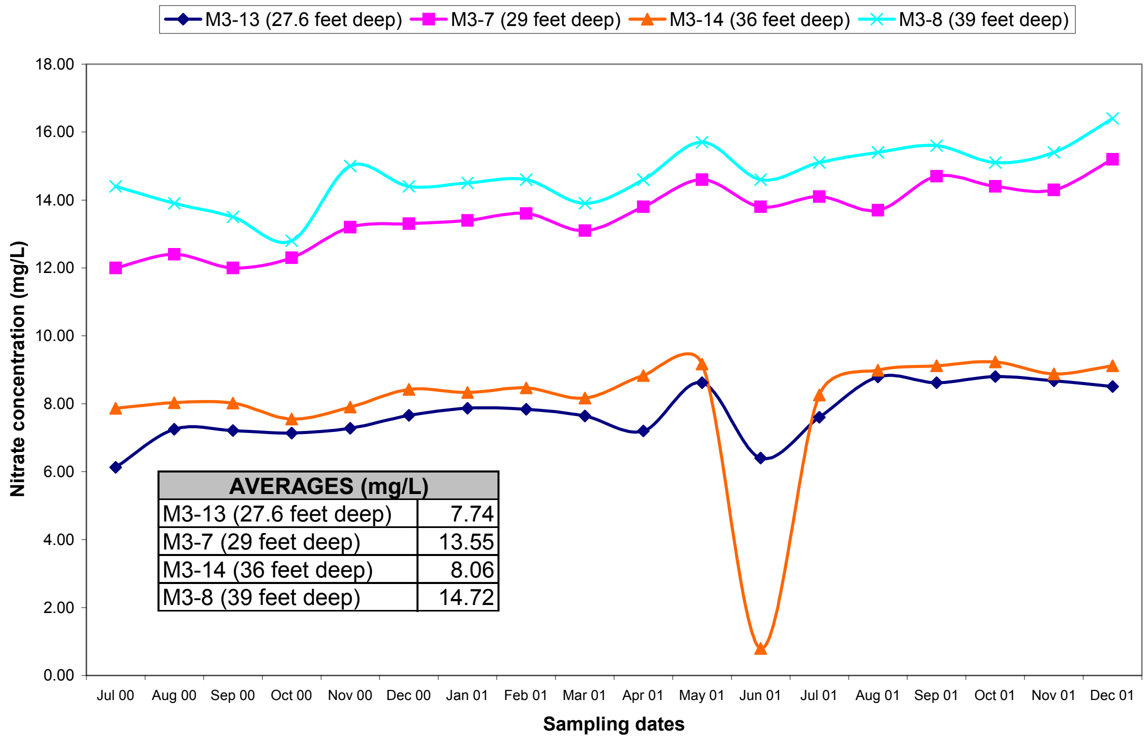


Figure 30. Time series plot of nitrate-nitrogen concentrations for intermediate wells at M-3.

Site M-3 has two deep wells with NO_3-N concentrations that ranged from 0.55 to 5.58 mg/L. M3-4 (93 feet deep) had significantly higher NO_3-N concentrations than M3-5 (153 feet deep). Figure 31 is a time series plot of NO_3-N concentrations from M3-4 and M3-5. The highest NO_3-N concentration at M3-4 was 5.58 mg/L during the April 19, 2001 sampling event. The highest NO_3-N concentration at M3-5 was 1.31 mg/L during the July 18, 2001 sampling event. The average NO_3-N concentration for M3-4 was 5.03 mg/L while the average NO_3-N concentration for M3-5 was 0.72 mg/L. The time series plots clearly shows a zonation of NO_3-N concentration that decreases as the depth of the monitoring well increases (Figure 31). Also, spatial correlation with higher nitrate was found on the east side of the drain, as with the shallow and intermediate wells.

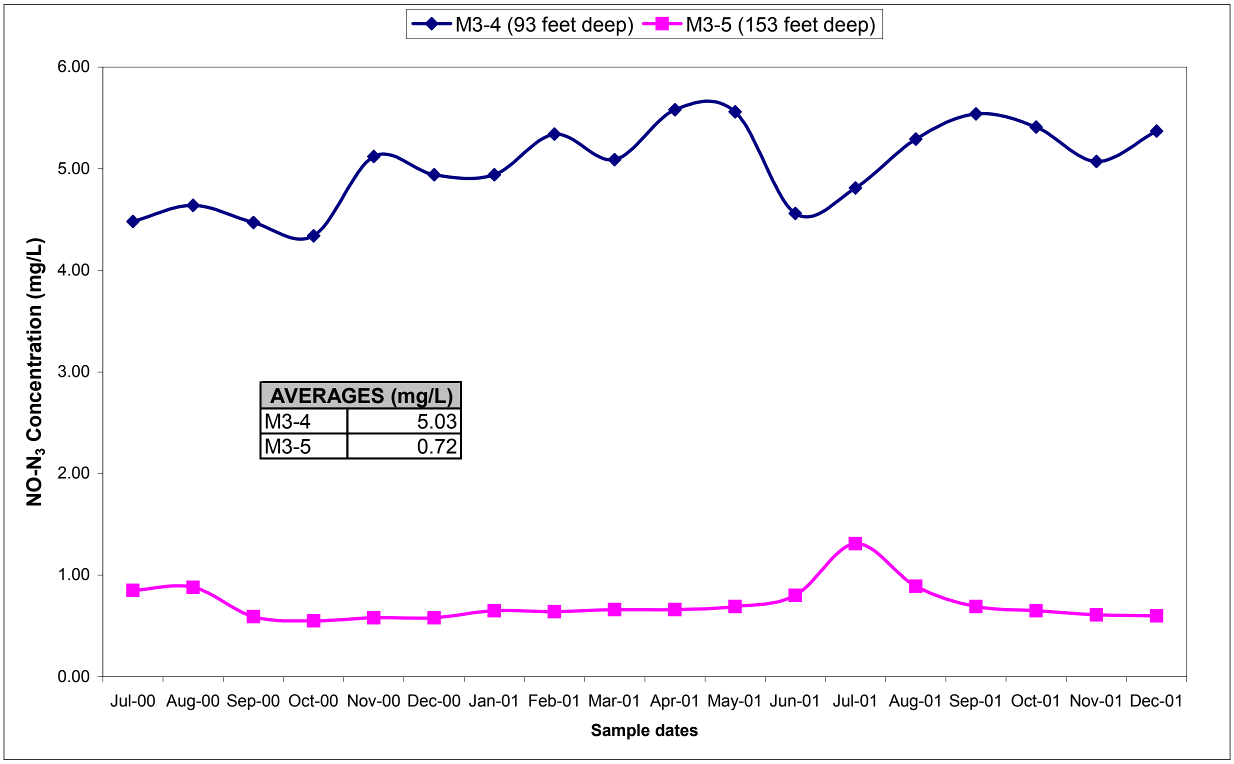


Figure 31. Time series plot of nitrate-nitrogen concentrations for deep wells at M-3.

The shallow well average for all samples (9.25 mg/L) was higher than two intermediate wells average concentration with depths of 27.6 and 36 feet (Table 6). Two intermediate wells (depths 29 and 39 feet) had higher average NO_3-N concentrations than the shallow wells. The average NO_3-N concentration of all shallow well samples was greater than both of the deep wells average NO_3-N concentrations; and the average NO_3-N concentrations of each of the intermediate wells were greater than both of the deep wells average NO_3-N concentrations. Although there is no correlation between depth and NO_3-N concentrations within the intermediate aquifer, it is apparent that the deeper aquifer has significantly less NO_3-N than the shallow aquifer. Overall, the highest nitrate concentrations occurred between 29 to 39 feet in samples taken from intermediate wells.

Table 6. Summary data table of M-3 wells average nitrate-nitrogen concentrations.

Well Type	Depth of well (feet)	Well(s)	NO_3-N Average (mg/L)
Shallow Wells	19-25	All Shallow Wells	9.25
Intermediate Wells	27.6	M3-13	7.74
	29	M3-7	13.55
	36	M3-14	8.06
	39	M3-8	14.72
Deep Wells	93	M3-4	5.03
	153	M3-5	0.72

Contour maps were made of M-3 using NO_3-N concentrations of the shallow wells. January, April, August, and November were chosen to represent different seasons in the agricultural year (Figure 32). Figure 32 shows an area of high NO_3-N concentration in the ground water that appeared to advance from the southeast to northwest as time progressed. The fields adjacent to monitoring wells had previously been planted with alfalfa, but were dormant during the farming season of 2000. During the farming season of 2001, the fields were irrigated to revive the alfalfa crop from past seasons. Contouring suggests that August and November of 2001 had a much larger geographic area of higher ground water NO_3-N concentrations than August and November of 2000. The area of higher NO_3-N concentration may be the consequence of NO_3-N migration as a result of the flood irrigation on the alfalfa fields during the 2001 growing season or potential impacts from off-site locations.

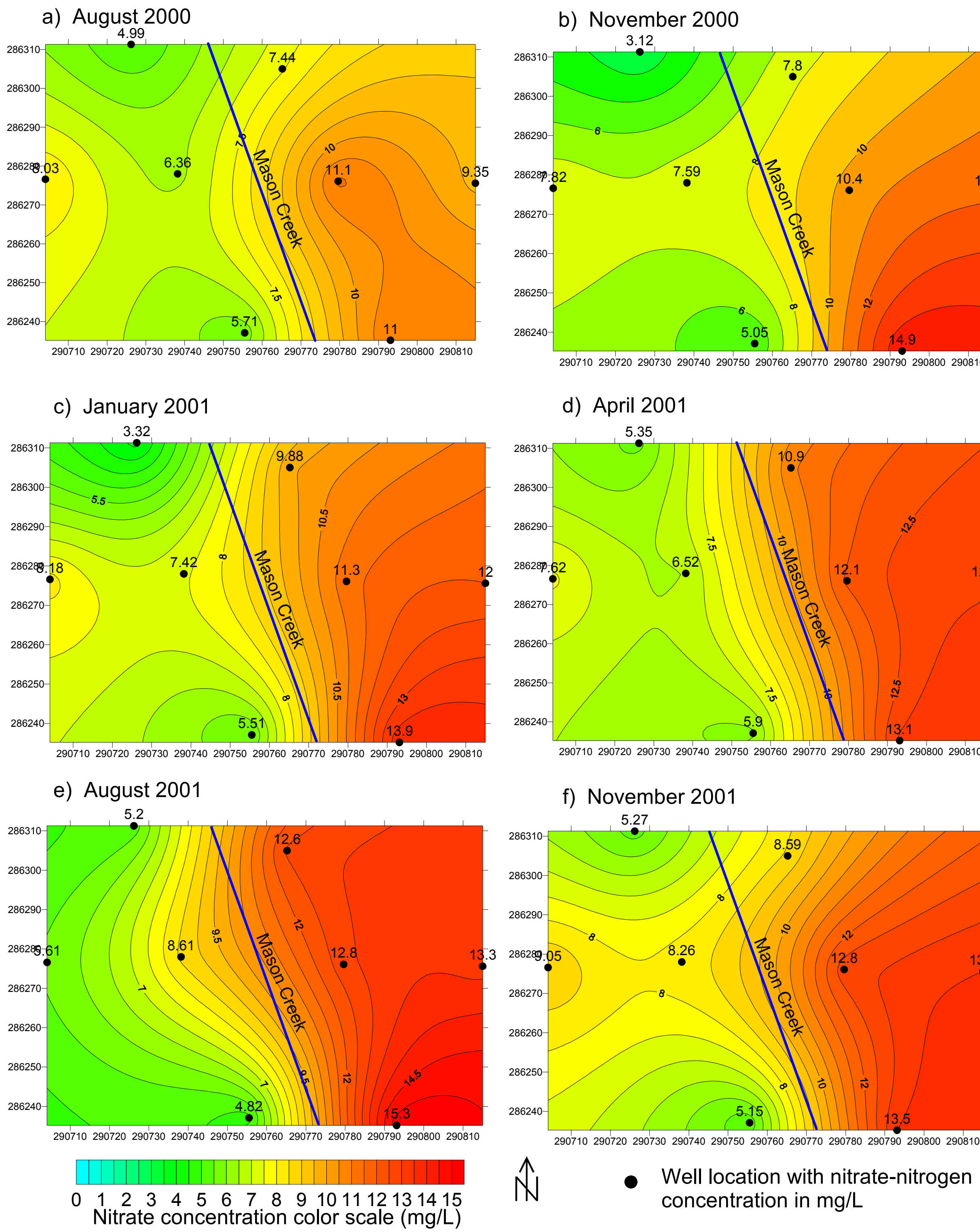


Figure 32. Contour maps of M-3 shallow ground water nitrate-nitrogen concentrations.

M-3 Surface Water Nitrate-Nitrogen

A surface water sample was collected from Mason Creek at M-3 every month during this study. On September 12, 2001 the water sample had a NO_3-N concentration of 4.7 mg/L, which was the highest surface water NO_3-N concentration recorded at M-3. The lowest concentration was 2.19 mg/L during the September 27, 2000 sampling event. The average NO_3-N concentration for all 16 samples was 3.43 mg/L. Average NO_3-N concentrations were calculated for the irrigation season (mid April to mid October) and for the non-irrigation season (late October to early April). The irrigation season average NO_3-N concentration was 3.14 mg/L, which was calculated from nine samples. The non-irrigation season average NO_3-N concentration was 3.81 mg/L, which was calculated from seven samples.

The daily load of NO_3-N was calculated using instantaneous discharge and associated concentration of NO_3-N. Daily NO_3-N loads ranged from 192 to 1160 pounds/day. The average NO_3-N load for all sampling events was 690 pounds/day. The irrigation season average NO_3-N load is 510 pounds/day, calculated from four samples; while the non-irrigation season average is 834 pounds/day, calculated from five samples.

The lag time from when irrigation water applied to the land infiltrates into the ground water system and reaches Mason Creek could potentially cause a greater NO_3-N load during the non-irrigation season. The water that infiltrates from the fields is NO_3-N enriched from fertilizers during the irrigation season, but may not reach Mason Creek until the non-irrigation season because of the travel time of ground water.

Loads at Mason Creek increase downstream from site M-3 to M-1. M-3 had an average NO_3-N load of 690 pounds/day; while M-1 had an average load of 1251 pounds/day, almost double the load at M-3. This data indicates that Mason Creek gained water and potentially NO_3-N as it flows downstream. Mason Creek empties into the Boise River; subsequently the NO_3-N load is added to the Boise River.

M-3 Ground Water Orthophosphorous

Orthophosphorous concentrations of the shallow wells (less than 25 feet deep) ranged from 0.24 to 0.48 mg/L at M-3. Average concentrations were calculated for each monthly sampling event, as seen in Figure 33. For M-3 shallow wells, the highest monthly average orthophosphorous concentration was 0.38 mg/L during the September 27, 2000 sampling event. The lowest average orthophosphorous concentration for shallow wells was 0.26 mg/L during the May 24, 2001 sampling event. The average orthophosphorous concentration for shallow wells for all sampling events was 0.35 mg/L.

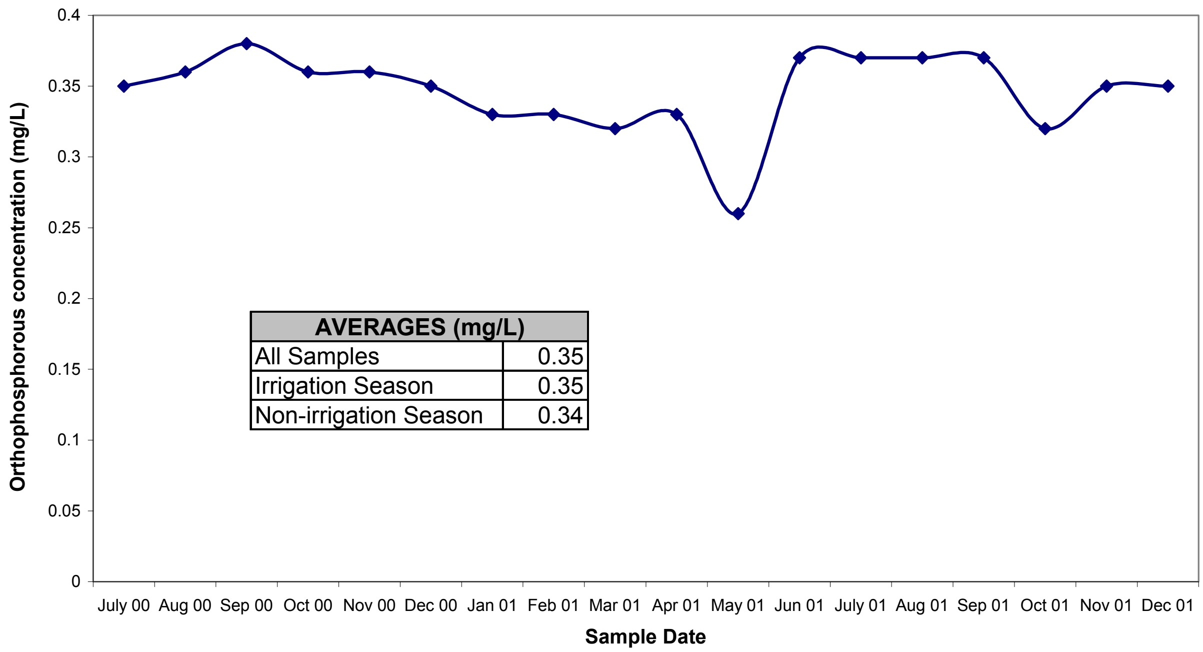


Figure 33. Time series plot of average orthophosphorous concentrations for M-3 shallow wells.

Orthophosphorous concentrations of the intermediate wells (between 25 to 55 feet deep) ranged from 0.10 to 0.35 mg/L at M-3. Figure 34 is a time series plot that graphs each intermediate depth wells orthophosphorous concentration. Average concentrations were calculated for each separate well, as seen in Figure 34. As the well depth increases within the intermediate and shallow ground water, the average orthophosphorous concentration decreases.

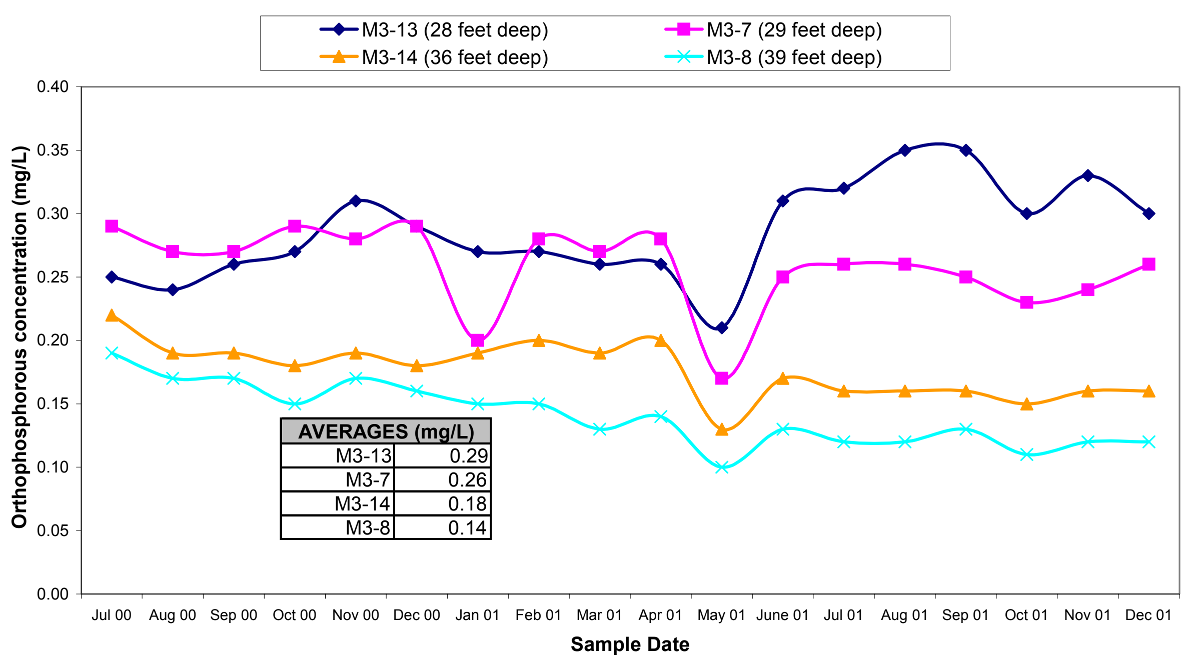


Figure 34. Time series plot of orthophosphorous concentrations for intermediate wells at M-3.

The orthophosphorous concentrations of the two deep wells located at site M-3 ranged from a non detect (<0.05 mg/L) to 0.10 mg/L. Monthly orthophosphorous concentrations for each well were plotted as a time series graph, as seen in Figure 35. Average orthophosphorous concentrations for M3-4 and M3-5 were 0.08 mg/L and 0.05 mg/L, respectively. The deep well (M3-5) has two dips that appear to be a large decrease in concentration. The decrease constitutes 0.07 mg/L of orthophosphorous. The enormity of decrease may be somewhat misleading due to the scale of the graph. Figure 35 shows that the orthophosphorous concentration continues to decrease as the sample depth increases.

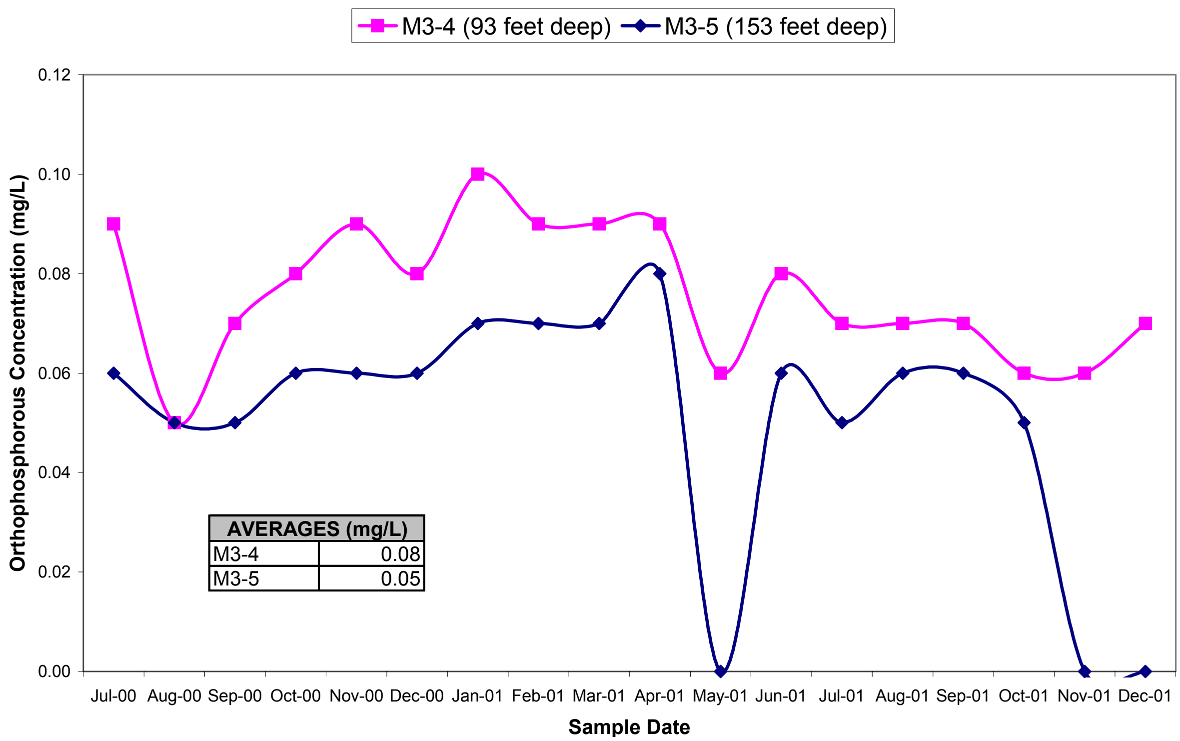


Figure 35. Time series plot of orthophosphorous concentrations for deep wells at M-3.

A correlation between depth of the water sample and orthophosphorous concentration is observed at M-3. The average orthophosphorous concentration decreases as depth increases. The average orthophosphorous concentration for all shallow wells is greater than the average concentrations for each of the intermediate wells (Table 7). The average orthophosphorous concentration of each intermediate well decreases with increasing depth, and the two deep wells average orthophosphorous concentration is less than the shallow and intermediate wells average concentrations.

Table 7. Summary data table for average orthophosphorous concentrations at M-3.

Well Type	Depth of well (feet)	Well(s)	Orthophosphorous Average (mg/L)
Shallow Wells	19-25	All Shallow Wells	0.35
Intermediate Wells	27.6	M3-13	0.29
	29	M3-7	0.26
	36	M3-14	0.19
	39	M3-8	0.14
Deep Wells	93	M3-4	0.08
	153	M3-5	0.05

Contour maps were made of the site using orthophosphorous concentrations of the shallow wells (Figure 36). The contour maps show that the highest concentrations of orthophosphorous within the project site are geographically located southwest of Mason Creek during August and November of 2000. The orthophosphorous could potentially leach from active fields located southwest of the project site into the ground water, which flows to the northeast towards Mason Creek and the monitoring wells on the west side of the drain. The leaching of orthophosphorous from fields to the southwest of the project site could explain the elevated levels of orthophosphorous detected in the ground water west of the drain. As mentioned in the discussion for the ground water NO_3-N concentration section, the fields directly surrounding the monitoring wells were not used during the 2000 sampling events. During the 2001 growing season, the fields were flood irrigated to revive the alfalfa that was planted in past growing seasons. An increase in the geographic extent of high orthophosphorous concentrations within the ground water on the east side of Mason Creek during August and November of 2001 is evident in Figure 36. The flood irrigation may be a factor in the high orthophosphorous concentration within the shallow aquifer. The irrigation water leached orthophosphorous into the shallow ground water, which was then detected in the monitoring wells. Another plausible source of orthophosphorous could be naturally derived from phosphorous bearing rocks and minerals found in the alluvial sediments.

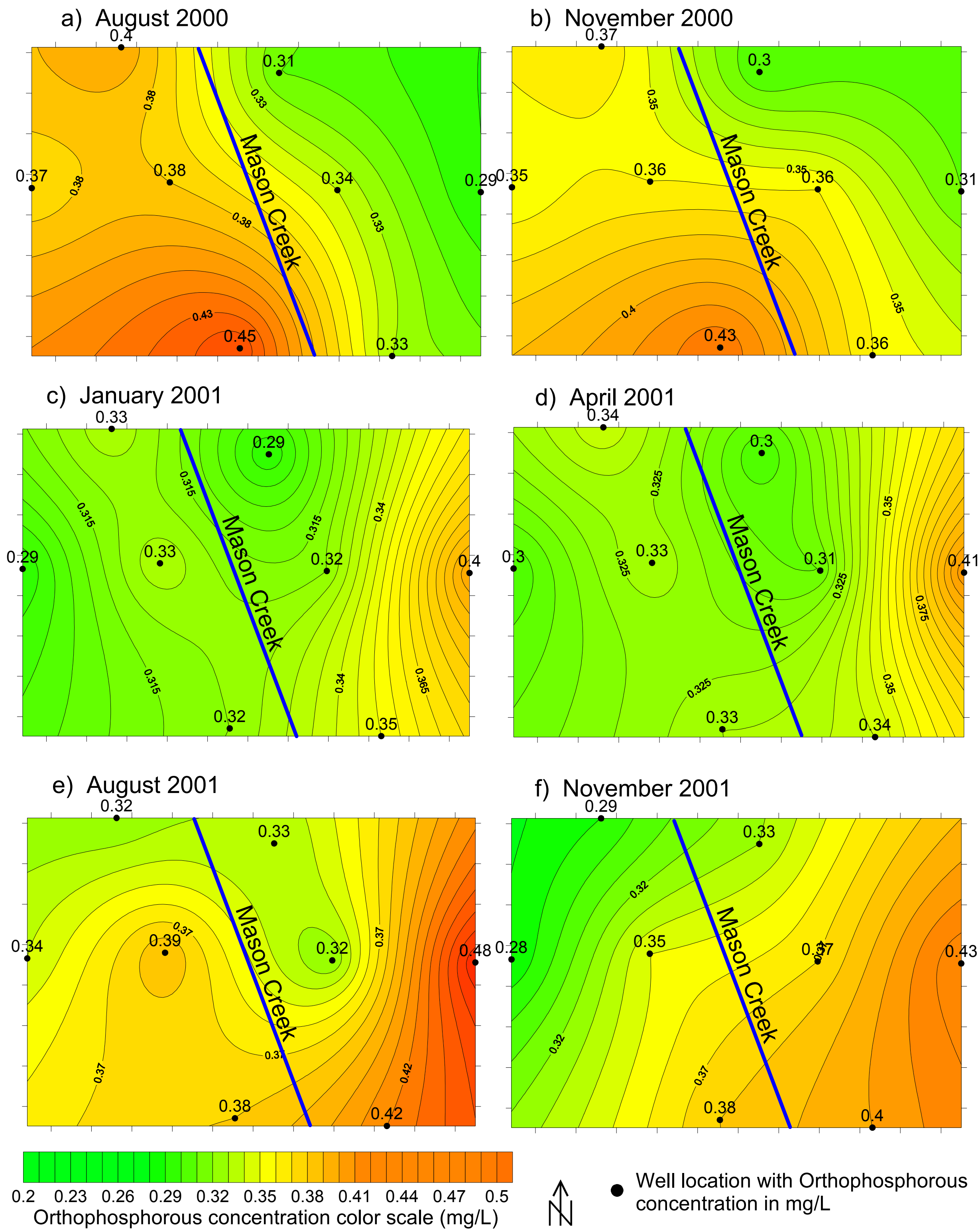


Figure 36. Contour map of orthophosphorous concentration at M-3.

M-3 Surface Water Orthophosphorous

Surface water samples from M-3 were also analyzed for orthophosphorous. The highest surface water orthophosphorous concentration recorded at site M-3 was 0.27 mg/L during the July 18, 2001 sampling event. The lowest surface water concentration recorded was 0.14 mg/L during the following four months of 2001: March, April, May and October. The average orthophosphorous concentration for all 17 samples was 0.18 mg/L. Average orthophosphorous concentrations were calculated for the irrigation season (mid April through mid October) and for the non-irrigation season (late October through early April). The irrigation season average orthophosphorous concentration was 0.19 mg/L, which was calculated from nine samples. The non-irrigation season average orthophosphorous concentration was 0.16 mg/L, which was calculated from eight samples.

The daily load of orthophosphorous was calculated using the instantaneous discharge and associated concentration of orthophosphorous for each sampling event. Daily orthophosphorous loads ranged from 13 to 63 pounds/day. The mean orthophosphorous load for all sampling events was 35 pounds/day. The irrigation season mean orthophosphorous load was 32 pounds/day, calculated from six discharge measurements; while the non-irrigation season mean was 40 pounds/day, calculated from three discharge measurements.

Loads at Mason Creek increase downstream from site M-3 to M-1. M-3 had an average orthophosphorous load of 35 pounds/day. Downstream at site M-1 the average orthophosphorous load increased to 74 pounds/day. This data indicates that Mason Creek at M-3 gained water and potentially orthophosphorous as it flows downstream during 2001. Mason Creek empties into the Boise River; subsequently the NO_3-N and orthophosphorous load is added to the Boise River.

M-3 Soil Nitrate-Nitrogen Concentrations

Soil samples were taken at site M-3 on May 23, 2001. The locations of the soil sampling sites for M-3 are shown on Figure 37. M-3 sampling results are listed in Appendix C. Each soil sample location was sampled at various depths (0.5, 1, 2, 3, 4 and 5 feet) when possible. Average NO_3-N concentrations were calculated for each sampling depth from each sample location. The M-3 site had the highest mean NO_3-N soil concentrations at the one-ft sample depth with 16 ppm. Nitrate-nitrogen concentration generally decreased with increased sample depth. The general trend of decreased NO_3-N concentration with increased depth can be seen in Figures 38 and 39, which are plots of nitrogen concentration versus sampling depth. M3-S1 and M3-S2 have very large concentrations that do not decrease as quickly as concentrations observed in other soil samples. M3-S1 and M3-S2 are both located to the east of Mason Creek, which is the area that has the highest NO_3-N concentrations within the ground water.

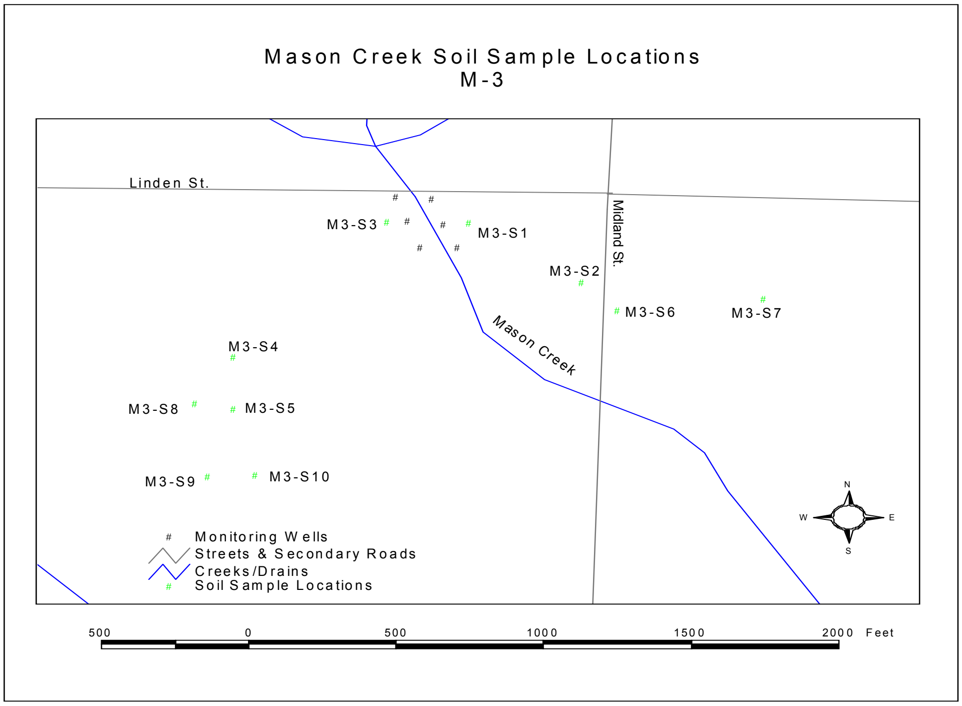


Figure 37. Soil sample locations at site M-3.

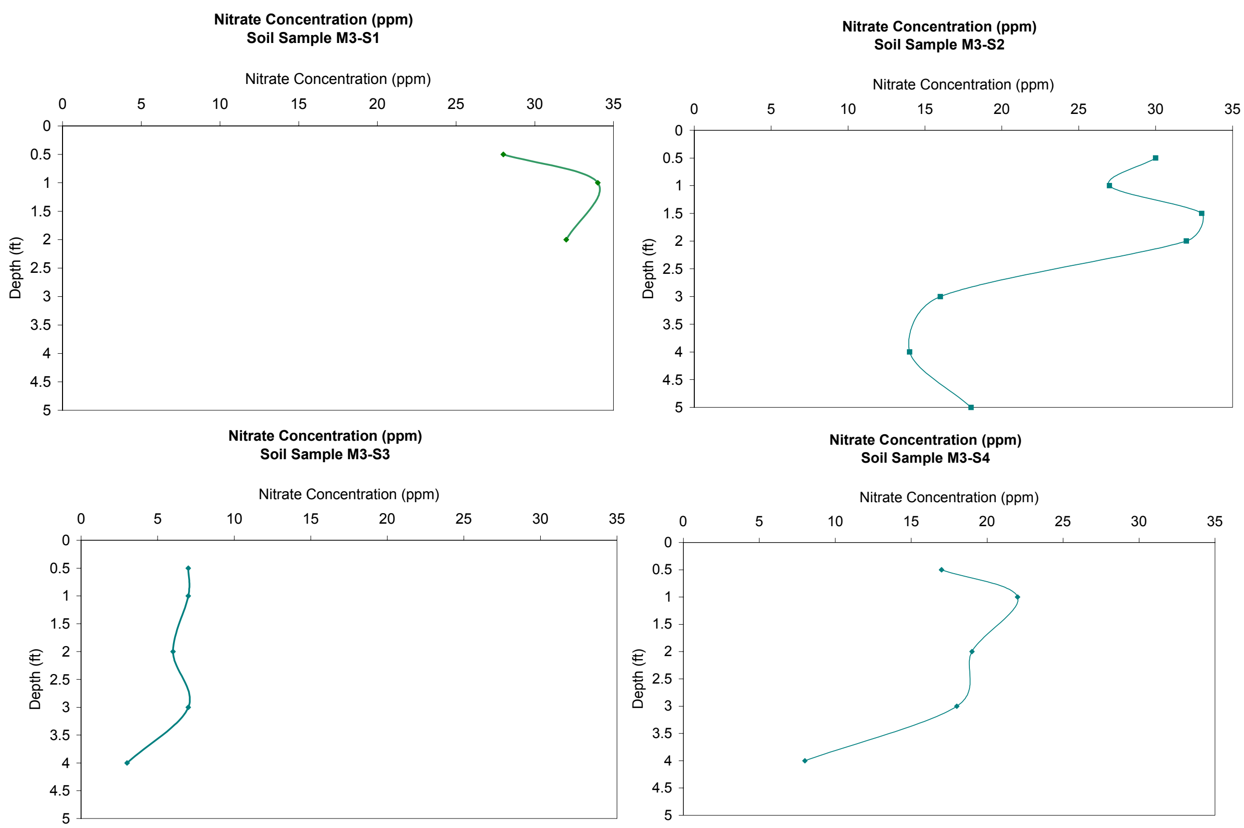


Figure 38. Depth integrated nitrate-nitrogen concentrations, site M-3; samples M3-S1 through M3-S4.

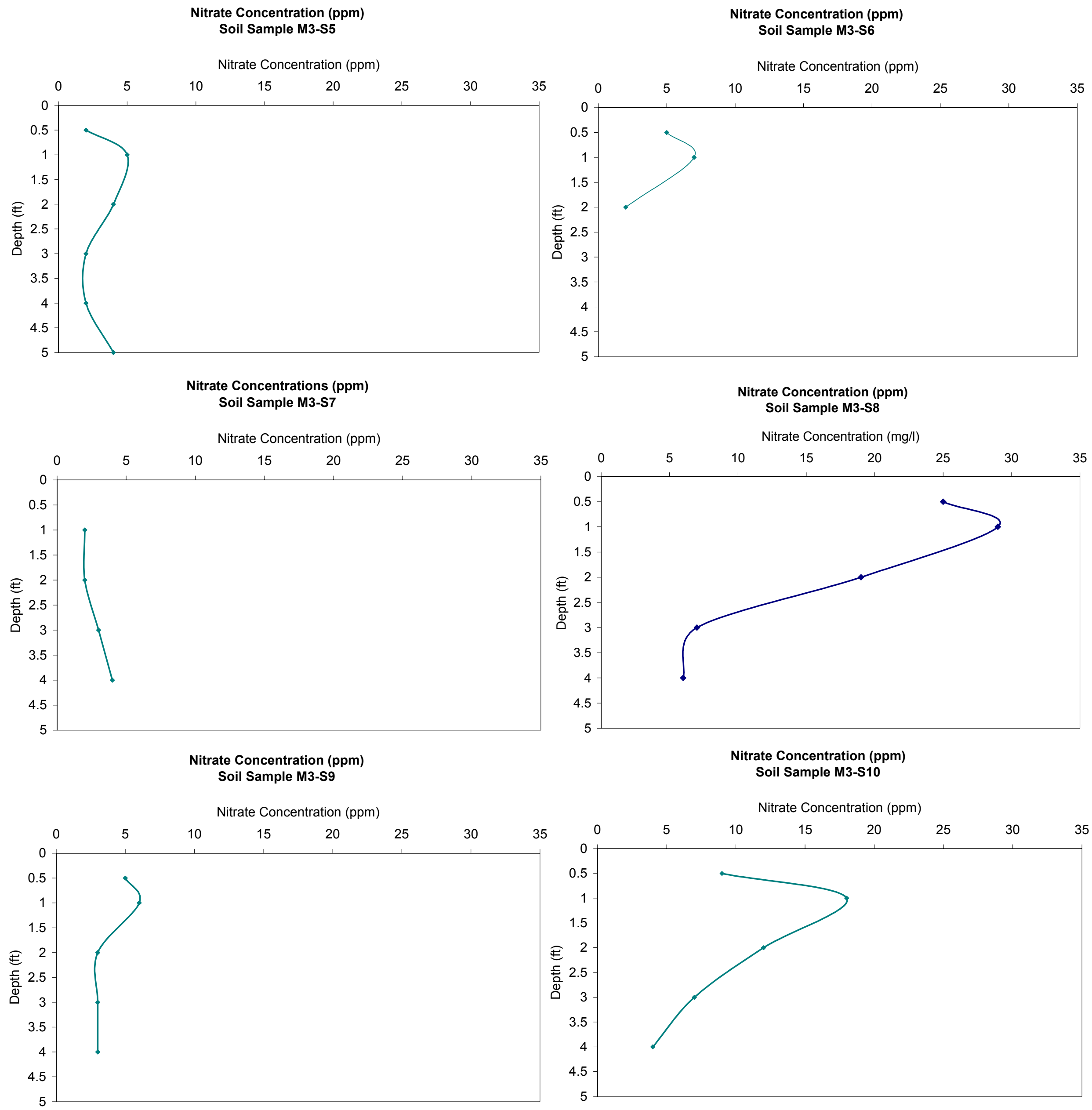


Figure 39. Depth integrated nitrate-nitrogen concentrations, site M-3; samples M3-S5 through M3-S10.

Soil samples at depths of 0.5 feet had an average NO_3-N concentration of 14 ppm. The geographic areas of high NO_3-N concentrations were east of Mason Creek and alfalfa fields located to the west of Mason Creek. The geographic areas of high NO_3-N concentrations for each sample depth can be seen on Figure 40, which shows the NO_3-N concentration at each soil sample location for each sample depth. The average NO_3-N concentration for the one-ft sampling depth was 16 ppm and the geographic areas of high NO_3-N concentrations are again east of Mason Creek and southwest of the well locations. Soil samples collected at the two-ft interval had a NO_3-N concentration mean value of 13 ppm. The geographic areas of high concentrations are similar to those observed at the 0.5 and one-ft sampling depth. Average NO_3-

N concentration for the three-ft sampling depths dropped to eight ppm. The areas of highest NO_3-N concentrations is again southwest and southeast of the well locations. Soil samples taken at four-ft below the ground surface are low in concentration, with no apparent geographic areas of high NO_3-N concentrations. The average value at the four-ft sampling interval was six ppm.

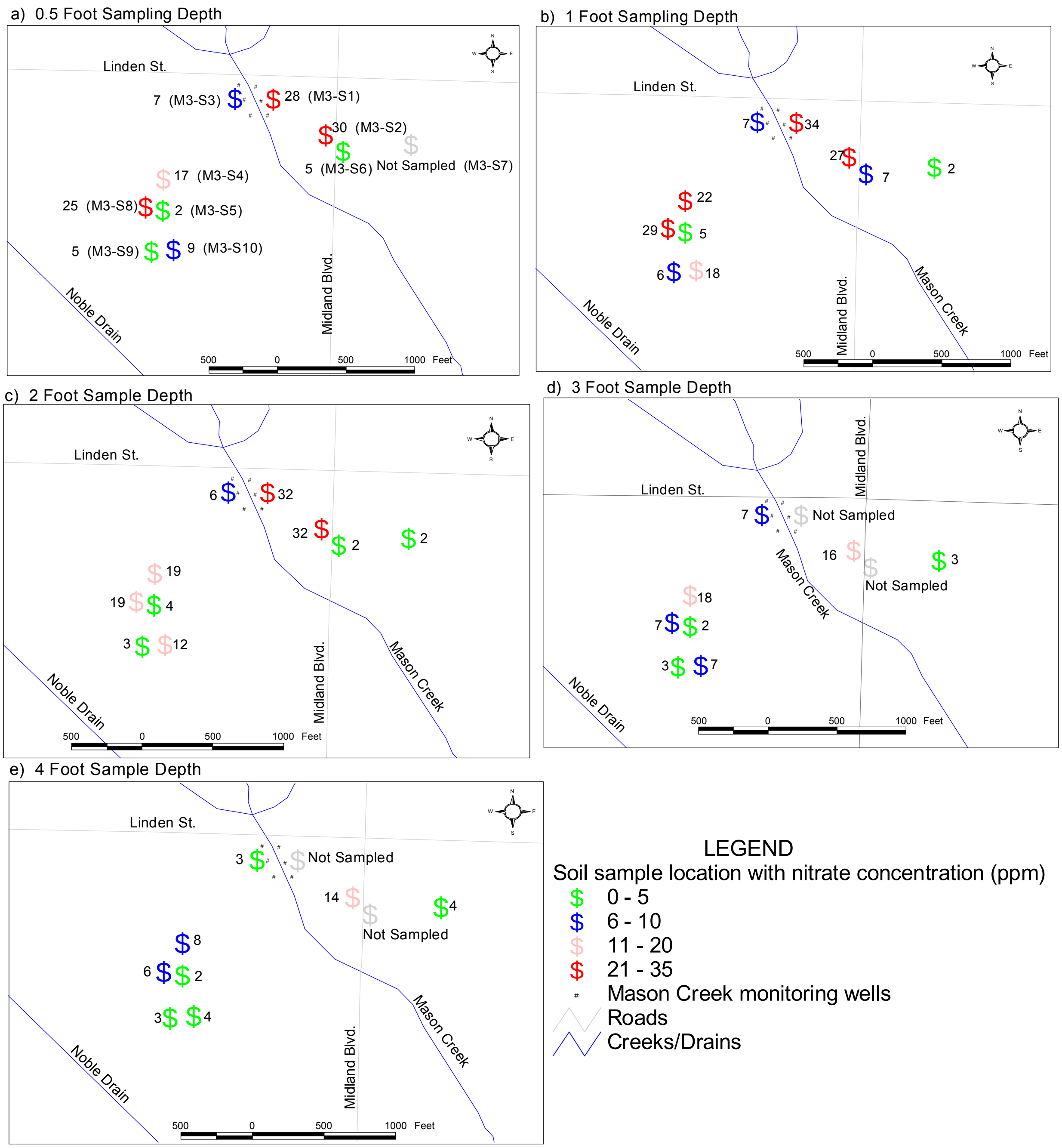


Figure 40. Soil nitrate-nitrogen concentration (ppm) and geographic location at site M-3.

M-3 Soil Phosphorous Concentrations

Soil samples collected at M-3 were also analyzed for phosphorous. Average soil phosphorous concentrations at site M-3 decreased with increasing soil depth, similar to NO_3-N concentrations. The highest average phosphorous concentration was 14 ppm, which occurred at the 0.5-ft sampling depth. The average phosphorous concentration at the one-ft sampling depth was 13 ppm. The two-ft sampling depth had an average concentration of 10 ppm. The average phosphorous concentration at three-ft was nine ppm, and the lowest average concentration was eight ppm at the four-ft depth.

Most soil samples decreased in phosphorous concentration as the sample depth increased. This trend can be seen in Figures 41 and 42, which plots the phosphorous concentration versus sampling depth. The exception to this is soil sample M3-S10, which increased over 20 ppm between the two and three-ft sampling intervals. Phosphorous concentrations at the three and four-ft interval of M3-S10 were higher than the phosphorous concentration at the 0.5 and one-ft intervals, which is not observed in any other soil sample at site M-3. M3-S10 was located to the south west of Mason Creek. Total phosphorous and orthophosphorous concentrations within the ground water increased to the southwest of Mason Creek during the 2001 farming season, which corresponds to the location of soil sample M3-S10.

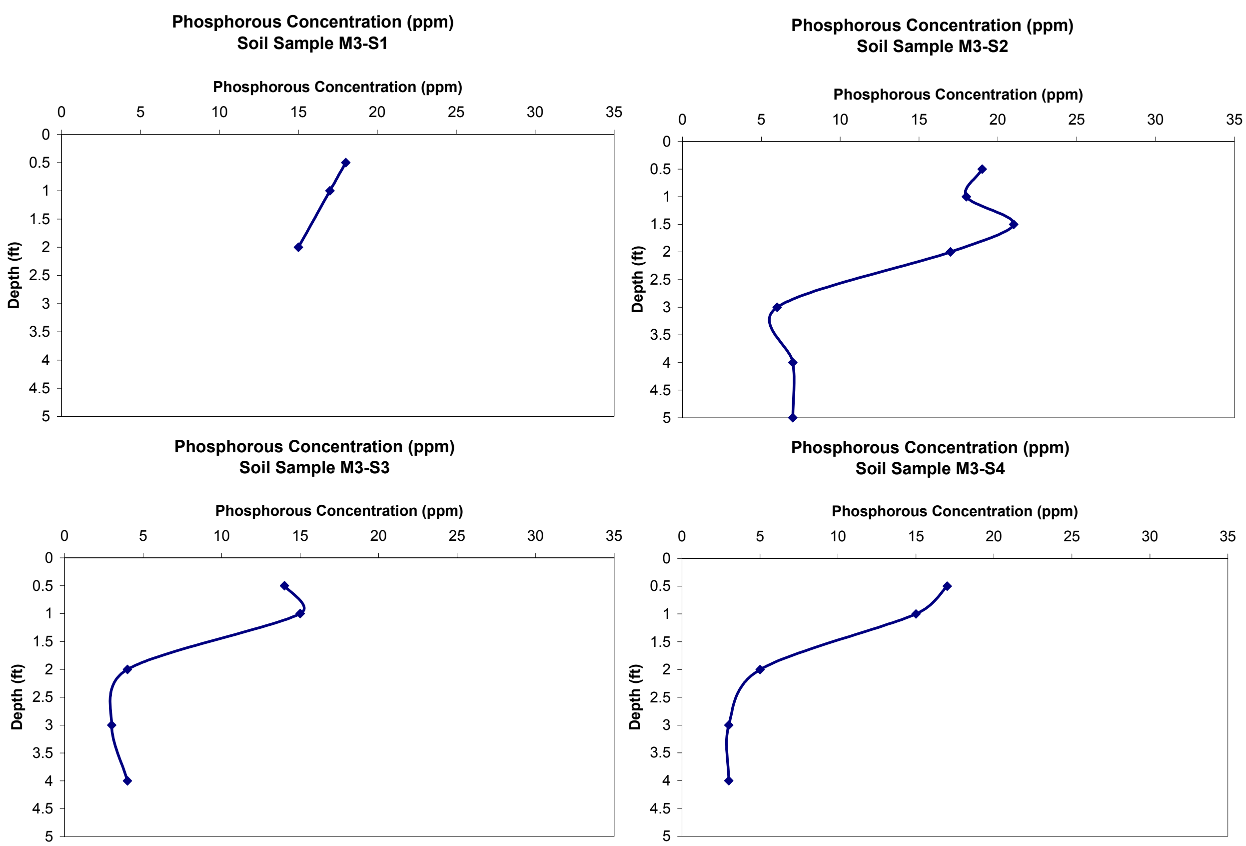


Figure 41. Soil phosphorous concentration versus sampling depth, site M-3; samples M3-S1 through M3-S4.

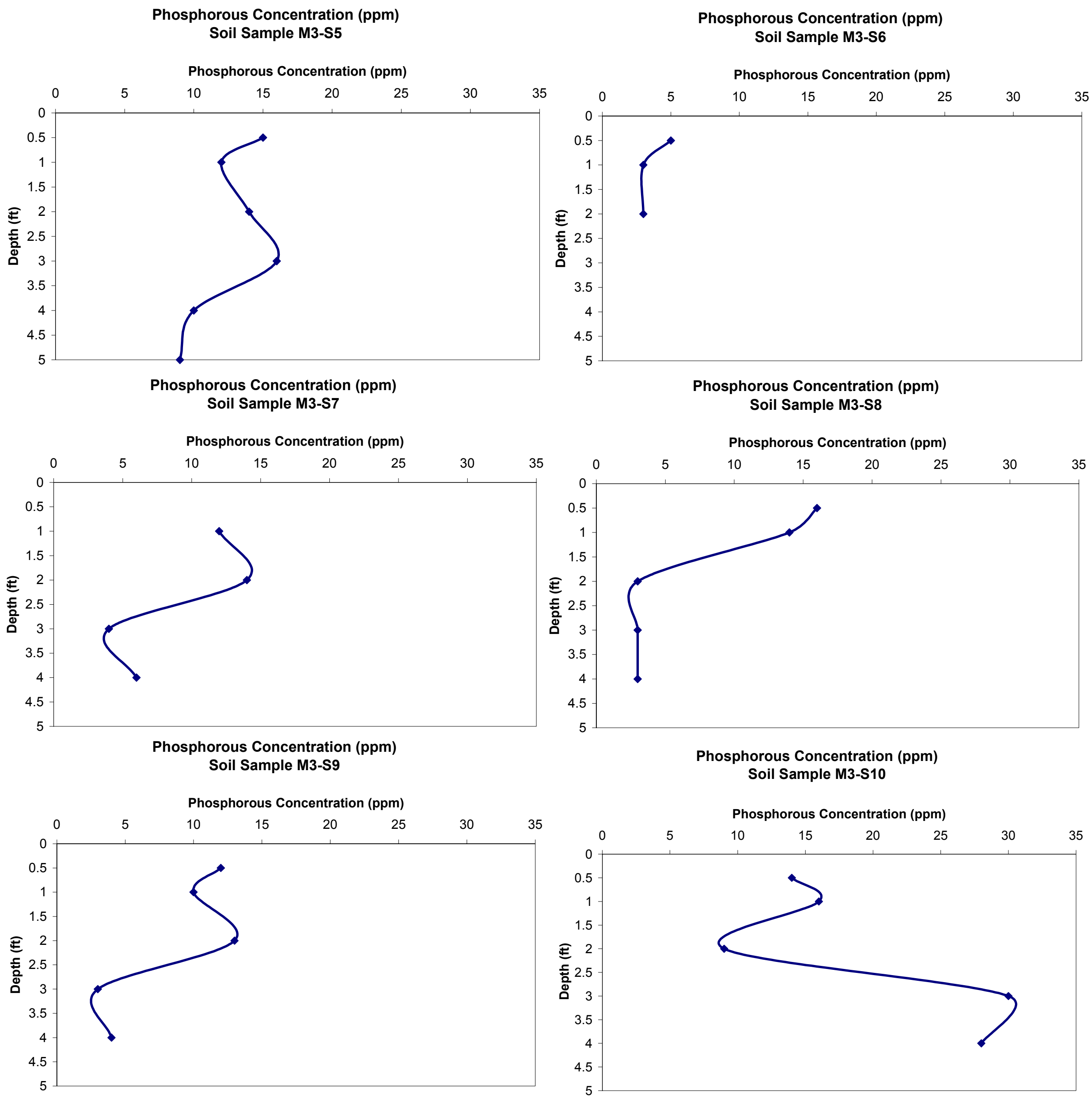


Figure 42. Soil phosphorous concentration versus sampling depth, site M-3; samples M3-5 through M3-S10.

The geographical areas of high concentrations are located east and southwest of Mason Creek for the 0.5 through two-ft sample depths, similar to high NO_3-N concentration locations (Figure 43). The three and four-ft sample depths indicate a high concentration of phosphorous to the southwest of Mason Creek, near alfalfa fields that had recently been irrigated prior to sampling.

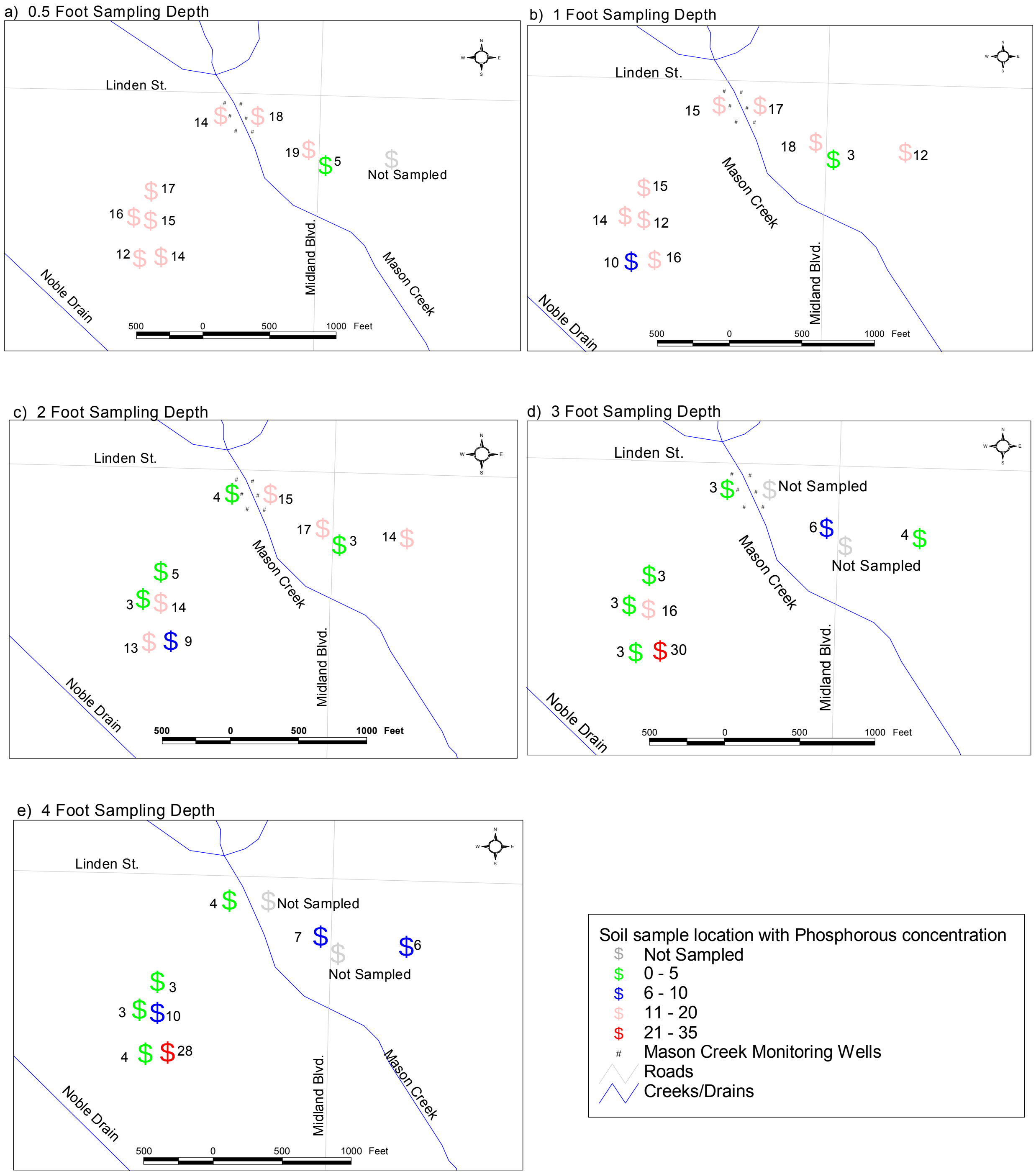


Figure 43. Soil phosphorous concentration (ppm) and geographic location at site M-3

M-3 Regression Analysis

Analytical data, over time, from ground water and surface water samples at site M-3 were used to complete a linear regression analysis. Several different plots were created: 1) using all data points, 2) using irrigation season data, and 3) using non-irrigation season data. These different plots were further broken into two groups: 1) using raw data points and 2) using averages of the four shallow wells from both sides of Mason Creek from each sampling event (wells M3-1, M3-2, M3-3, and M3-6 were averaged together; and wells M-9, M3-10, M3-11, and M3-12 were averaged together). The plots are included as Appendix F. A few bivariate relationships were observed based on the coefficient of determinant (R^2) and F test findings. Prior to the analysis a significance level of 0.1 was selected for a statistical F test. Several regressions did not meet the statistical F test level of 0.1 and were omitted from the appendix. There were few obvious statistical correlations from the data. Most R^2 values were less than 0.50, but all F test findings met the significance level of 0.1 of the plots included in this report. While the trend in not strong, there is a statistical relationship that is evident. One regression did show that as ground water elevation rose, the NO_3-N, total phosphorous and orthophosphorous concentrations in the ground water also increased. The relationship between average ground water elevation and average total phosphorous was the strongest regression plot with a R^2 value of 0.6343 (Figure 44). This suggested potential leaching impacts to the ground water over the period of the study.

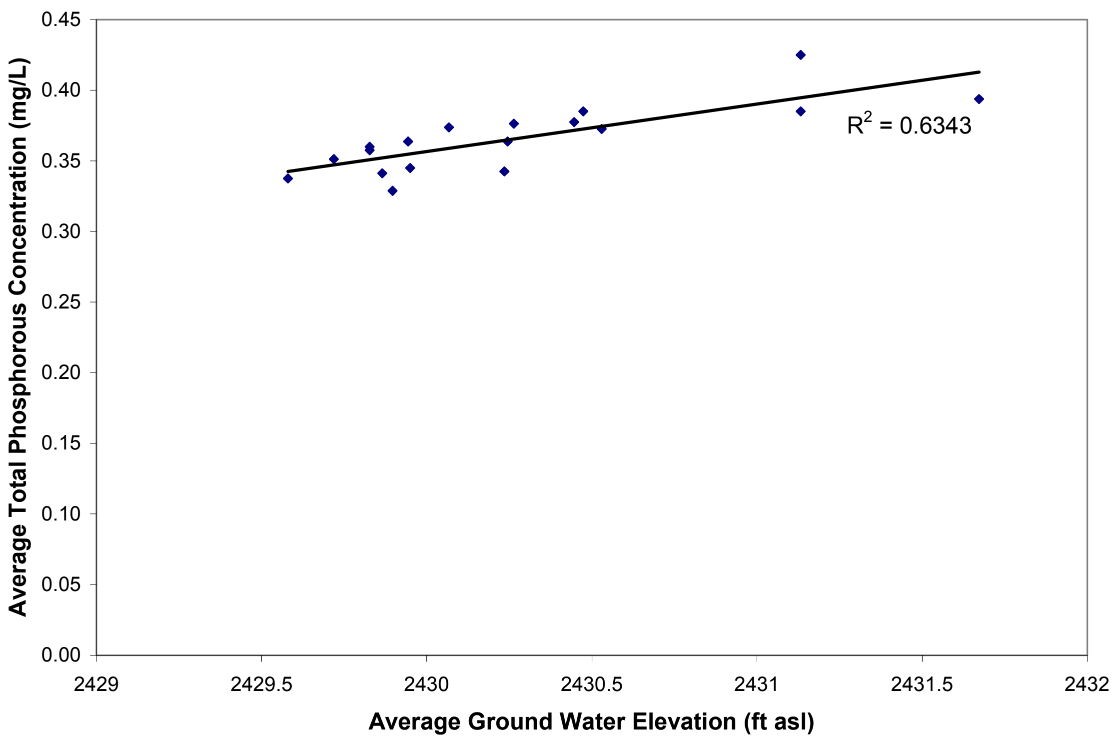


Figure 44. Regression plot for M-3 shallow wells for average ground water elevation versus average phosphorous concentrations.

M-3 Surface Water and Ground Water Interactions

Figure 45 is a time series plot for NO_3-N concentration of Mason Creek surface water and monthly mean NO_3-N concentrations of the shallow wells at site M-3. During the irrigation season, the surface water NO_3-N concentration has a general increasing trend. The non-irrigation season starts with high concentrations of NO_3-N in the surface water, which then slowly decreases.

The same trend occurs for the ground water orthophosphorous concentration during irrigation season, however, the increase is rapid at the beginning of the season and then decreases at the end of the season. The non-irrigation season orthophosphorous concentration within the ground water remains fairly constant until the beginning of the irrigation season. Overall, average ground water NO_3-N concentrations were two to four times higher than concentrations measured in the drain.

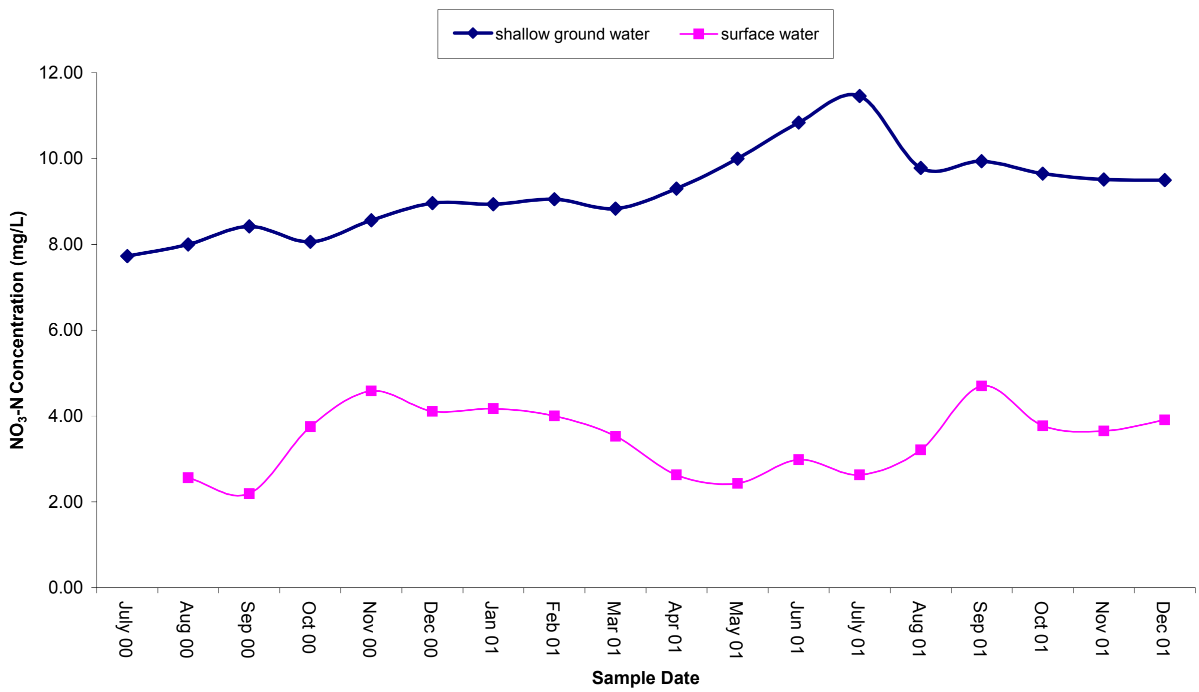


Figure 45. Time series plot of surface water and average shallow ground water nitrate-nitrogen concentrations at site M-3.

Ground water contribution of NO_3-N to Mason Creek was calculated by multiplying the net gain of discharge in Mason Creek at M-3 by the average shallow ground water NO_3-N concentration. During the months when M-3 was a losing portion of Mason Creek, the net loss of NO_3-N to the ground water was calculated by multiplying the net loss of discharge from Mason Creek by the surface water NO_3-N concentration. Figure 46 shows the NO_3-N load in pounds per month that ground water contributed to Mason Creek (positive y values) or that Mason Creek contributed to the ground water (negative y values) during the nine months in 2001 when flow measurements were taken. During the nine months in 2001, Mason Creek gained approximately a net total of

437 pounds of NO_3-N from the ground water at M-3. This accounts for 0.05% of the yearly NO_3-N load that Mullins (1998) calculated Mason Creek contributes to the Boise River.

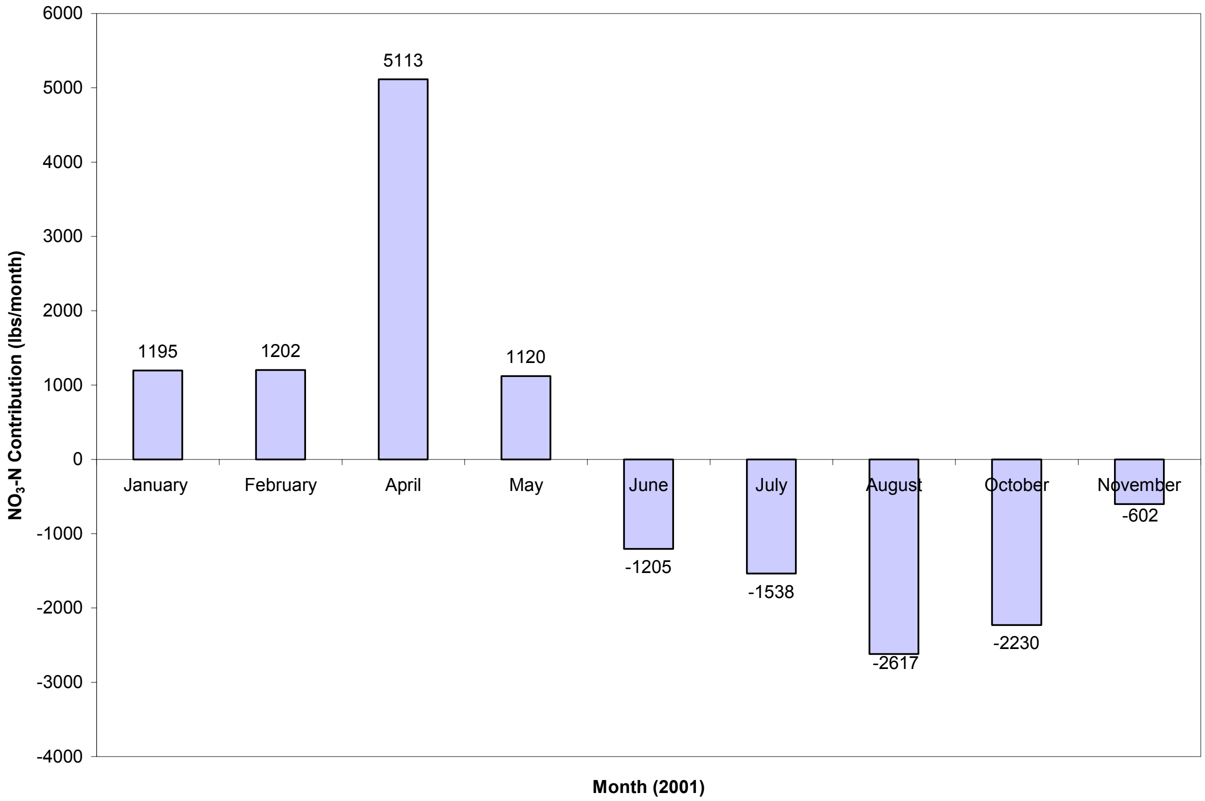


Figure 46. Ground water nitrate-nitrogen contribution to Mason Creek at site M-3 in 2001.

The average NO_3-N load contributed to Mason Creek by ground water during the four gaining months at site M-3 (Figure 46) was 72 pounds/day. The average daily contribution was used to determine the percentage of instantaneous NO_3-N load at site M-3 that was contributed by ground water. This was accomplished by dividing the instantaneous load at M-3, calculated by various studies, by 72 pounds/day. The results are shown in Table 8. The percentage of instantaneous NO_3-N load at site M-3 contributed by ground water was fairly consistent for each study.

Table 8. Nitrate-nitrogen load contributed to M-3 by ground water.

Study	Calculated instantaneous NO_3-N load of Mason Creek, Site M-3	Percentage of instantaneous NO_3-N load contributed by ground water, Site M-3
ISDA 1998-1999	1,029 lbs/day	7%
ISDA 1999-2000	996 lbs/day	7.2%
ISDA 319 study	690 lbs/day	10%

Ground water contributions of orthophosphorous to Mason Creek at site M-3 was calculated using the same methods as calculating the NO_3-N ground water contribution. Figure 47 shows the orthophosphorous load in pounds per month that ground water contributed to Mason Creek (positive y values) or that Mason Creek contributed to the ground water (negative y values). During the nine months in 2001 in which the loads were calculated, Mason Creek dispersed approximately a net total of 228 pounds of orthophosphorous to the ground water at M-3. However, the shallow ground water flow generally follows Mason Creek to the Boise River. The orthophosphorous that is dispersed into the shallow ground water from Mason Creek likely reenters the drain further upstream. If the shallow ground water does not reenter Mason Creek, it likely enters the Boise River, adding orthophosphorous to the system.

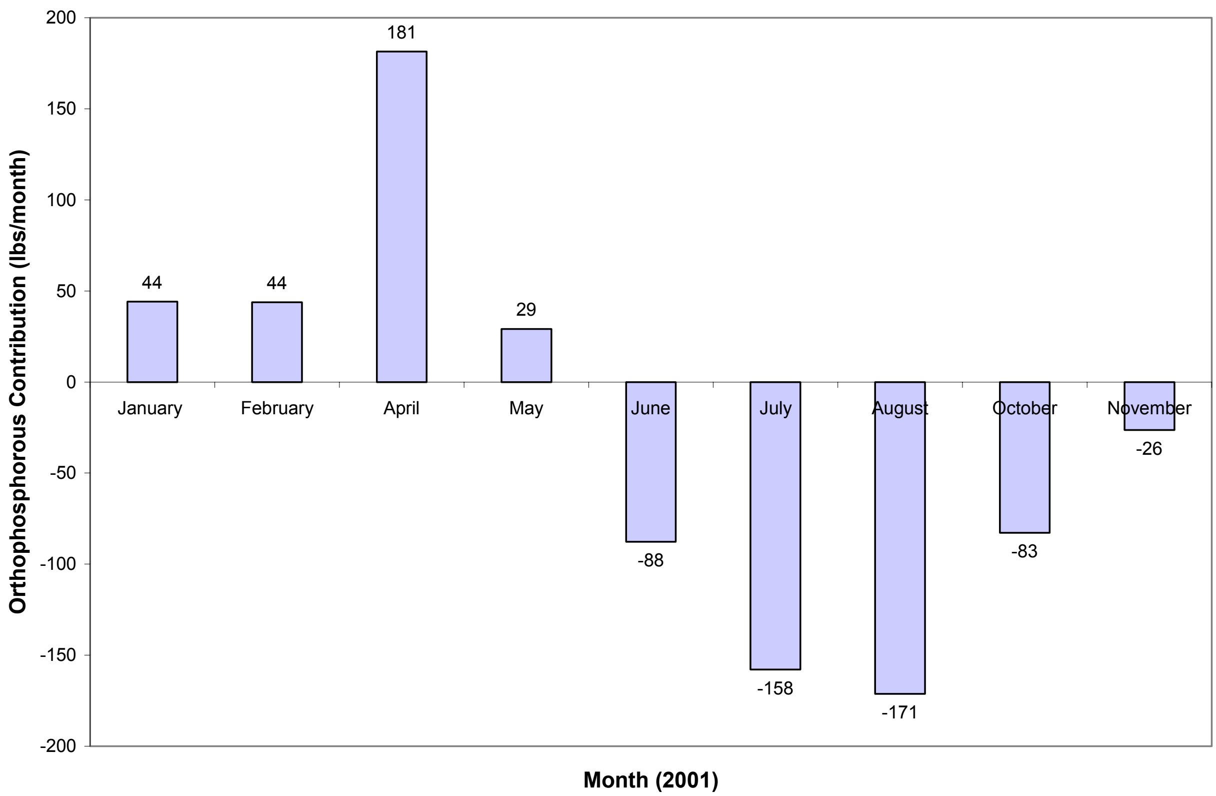


Figure 47. Ground water orthophosphorous contribution to Mason Creek at site M-3 in 2001.

The average orthophosphorous load contributed to Mason Creek by ground water during the four gaining months at site M-3 (Figure 47) was 2.5 pounds/day. The average daily contribution was used to determine the percentage of instantaneous orthophosphorous load at site M-3 that was contributed by ground water. This was done by dividing the instantaneous orthophosphorous load by 2.5 pounds/day. The results are shown in Table 9. The percentage of instantaneous orthophosphorous load at site M-3 contributed by ground water was fairly consistent for each study.

Table 9. Orthophosphorous load contributed to M-3 by ground water.

Study	Calculated instantaneous orthophosphorous load of Mason Creek, Site M-3	Percentage of instantaneous orthophosphorous load contributed by ground water, Site M-3
ISDA 1998-1999	59 lbs/day	4%
ISDA 1999-2000	57 lbs/day	4%
ISDA 319 study	35 lbs/day*	7%

*discharge was half of the 1998-2000 studies, which accounts for the lower instantaneous loads.

M-3 Nitrogen Isotope Concentrations

Results of $\delta^{15}N$ testing in 2000 at site M-3 returned values that ranged from 4.43 to 35.77$^{0}/_{00}$ (Table 10). $\delta^{15}N$ results can be used as an indicator of nitrogen sources. Four wells had values over 10$^{0}/_{00}$, suggesting a human or animal waste source. However, these high results could have been influenced by denitrification of commercial fertilizers or other sources. A denitrification evaluation was beyond the scope of this study. The rest of the eight wells had results between 4 to 10$^{0}/_{00}$, suggesting an organic or mixed source of NO_3-N. The surface water sample collected at site M-3 had a $\delta^{15}N$ result of 10.71$^{0}/_{00}$, which is in the low end of the nitrogen waste source range (over 10$^{0}/_{00}$).

Table 10. 2000 $\delta^{15}N$ results for site M-3.

Well ID	Sample Date	N-15 ($^{O}/_{OO}$)
M3-1	Dec-00	5.79
M3-2	Dec-00	35.77
M3-3	Dec-00	4.09
M3-6	Dec-00	5.69
M3-7	Dec-00	5.93
M3-8	Dec-00	4.48
M3-9	Dec-00	15.78
M3-10	Dec-00	11.13
M3-11	Dec-00	11.16
M3-12	Dec-00	4.94
M3-13	Dec-00	5.84
M3-14	Dec-00	5.36
M3-SW	Dec-00	10.71

Conclusions

General

Based on the results of this study the following conclusions concerning the interactions between surface water and ground water near an agricultural drain are presented:

1. The following goals and objectives of this study were met: (1) nutrient concentrations of shallow ground water entering the drain were characterized by field and lab analysis, (2) physical characterization of ground water flow direction and volume was completed based on lithologic and hydrogeologic characterization, (3) physical and chemical properties of the ground water and the drain were characterized by field and lab analysis, (4) nutrient contributions from on site or nearby locations were characterized, (5) quantification of ground water quality impacts to the drain from the ground water were characterized by calculating loads and (6) prior hydrogeologic and water quality studies in the vicinity were compared to validate this study's findings.

2. Sampling and lab work were within the QA/QC requirements set at the beginning of this project.

3. The landowners were very cooperative and flexible with ISDA requests for extra sampling (ie. soil sampling). Their cooperation was very much appreciated and a major factor of the successfulness of the project.

4. The study suggests agricultural fields can be a source of nutrients that leach into the shallow ground water. The shallow ground water can then flow into a drain, increasing the nutrient load of the surface water.

5. This study could be used as a model for a BMP effectiveness evaluation at an agricultural site.

Site M-1

Based on the results of this study the following conclusions concerning the interactions between surface water and ground water near Mason Creek at site M-1 are presented:

1. Average ground water NO_3-N concentrations of the shallow wells at M-1 were consistently higher than surface water NO_3-N concentrations at M-1, except for October and November of 2000 and 2001. October and November are the end months of the irrigation season, and the increase in surface water NO_3-N in comparison to ground water NO_3-N is, in part, the result of shallow ground water influence as M-1 changes to a gaining portion of Mason Creek.

2. The shallow ground water is potentially a significant source of NO_3-N loading to Mason Creek during the times when site M-1 is a gaining portion. Mason Creek is likely not a significant source of NO_3-N to the shallow ground water since the only time when the surface water had higher NO_3-N concentrations than the ground water were gaining periods

of Mason Creek at site M-1.

3. Site M-1 was a gaining portion of Mason Creek during January to May 2001 and October through November 2001, and a losing portion during June through August 2001. During the gaining periods, the shallow aquifer likely contributed NO_3-N and orthophosphorous to Mason Creek. During losing periods, Mason Creek contributed NO_3-N and orthophosphorous to the shallow aquifer. The calculated net gain of NO_3-N and orthophosphorous to Mason Creek from the shallow ground water at site M-1 was 17,076 and 650 pounds, respectively, for the nine months in which loads were determined.

4. Site M-1 had higher surface water loads of both NO_3-N and orthophosphorous than upstream site M-3 during both the irrigation and non-irrigation seasons. The average NO_3-N and orthophosphorous loads were almost double at site M-1 than site M-3. Mason Creek gains NO_3-N and orthophosphorous as it flows downstream.

5. The soil samples were collected as a one time sampling effort. Concentrations of NO_3-N and phosphorous within the soil indicated that the fields were sources of nutrients that leach into the soil. The samples collected showed a general trend of decreased NO_3-N and phosphorous concentration as sample depth increased. The soil sample taken in the pasture had lower NO_3-N and phosphorous concentrations than the other soil samples located near grassy yards. However, no soil testing was completed on nearby agricultural fields and waste application areas due to landowner permission problems. These fields likely contributed NO_3-N and orthophosphorous concentrations at the site.

6. Regression analysis of analytical data indicated that as ground water elevation increased the nitrate concentration decreased and the orthophosphorous and total phosphorous concentrations increased within the ground water. The R^2 values showed that the relationships were significant. This suggests that orthophosphorous and total phosphorous leach into the ground water during increased downward infiltration of water.

7. Isotope results were mixed. However, the results suggest several potential sources including organics, and animal and/or human wastes.

8. Further work is needed to quantify orthophosphorous concentrations resulting from natural sources (e.g. breakdown of alluvial sediments).

Site M-3

Based on the results of this study the following conclusions concerning the interactions of surface water and ground water around Mason Creek at site M-3 are presented:

1. Monthly sampling of shallow ground water for NO_3-N and orthophosphorous revealed increased concentration of the nutrients during the irrigation season of 2001. This is the same time that alfalfa fields adjacent to the monitoring wells were flood irrigated for the first

time during this study. The timing of the flood irrigation suggests that nutrients were leached into the ground water by the infiltration of the flood irrigation water.

2. Surface water loads of NO_3-N and orthophosphorous at M-3 were higher during non-irrigation season than during the irrigation season. This is in part due to shallow ground water influence as M-1 changes to a gaining portion of Mason Creek during the non-irrigation season. The shallow ground water had higher nutrient concentrations than Mason Creek, suggesting that during gaining times Mason Creek would have higher nutrient concentrations.

3. Average ground water NO_3-N concentrations were higher than all surface water NO_3-N concentrations at site M-3. This indicates that the ground water is a potentially significant source of NO_3-N loading when Mason Creek is a gaining stream at site M-3. Mason Creek is a nominal source of NO_3-N to the ground water when Mason Creek is a losing stream at site M-3.

4. Site M-3 was a gaining portion of Mason Creek during January to May 2001, and a losing portion during June through November 2001. During the gaining periods the shallow aquifer contributed NO_3-N and orthophosphorous to Mason Creek. During losing periods Mason Creek contributed NO_3-N and orthophosphorous to the shallow aquifer. The net gain of NO_3-N to Mason Creek from the shallow ground water from the nine calculated sampling events was 437 pounds, while the net loss of orthophosphorous from Mason Creek to the shallow aquifer was 228 pounds. However, because the shallow ground water flow path follows Mason Creek to the Boise River, the orthophosphorous in the shallow ground water can eventually return to the drain when it reaches a portion of Mason Creek that is gaining ground water. If the orthophosphorous does not return to Mason Creek, it could eventually be dispersed into the Boise River system.

5. Soil NO_3-N and phosphorous concentrations generally decreased as the sample depth increased. Areas of high nutrient concentrations occurred in the alfalfa fields, which were flood irrigated during 2001. Thus certain agricultural crops and locations can result in nutrient contributions to the ground water that can eventually flow into Mason Creek. Soil testing generally indicated a relationship between NO_3-N and orthophosphorous concentrations.

6. Regression analysis of analytical data indicated that as the ground water elevation increased, the nitrate, orthophosphorous, and total phosphorous concentrations increased within the ground water. The R^2 values of the regression analysis were very low, indicating that the relationships were not strong. However, the analysis suggests that NO_3-N, orthophosphorous, and total phosphorous leach into the ground water during increased downward infiltration of water.

7. Isotope results were mixed. However, the results suggest several potential sources including organics, and animal and/or human wastes.

8. Further work is needed to quantify orthophosphorous concentrations resulting from natural sources (e.g. breakdown of alluvial sediments).

Recommendations

Based on the results of the study, the ISDA recommends that measures to reduce nutrient impacts on ground water be addressed and implemented. The ISDA recommends that:

1. The methods and approach of this study could be used as a model for a BMP effectiveness evaluation for nitrate and phosphorous leaching at agricultural sites.

2. Findings from this study can be used to educate farmers, the Soil Conservation Districts, and other agricultural stakeholders.

3. Nutrient management plans should be implemented on farms to prevent leaching of nutrients into the shallow ground water.

To determine other potential contaminant sources, the ISDA suggests the following more intensive monitoring in the project area:

1. Subsurface flow characteristics measured by installation of lysimeters.

2. Continued monitoring of nutrients and field parameters to determine long term data trends.

3. Installation of pressure transducers in the wells.

4. Soil sampling over a period of time to track nutrient leaching rates.

5. Analysis of N^{15} over time to determine the potential sources of NO_3-N. Also, analysis of O^{18} over time to determine effects of denitrification on N^{15} results.

6. Analysis of irrigation transport in soil profiles during irrigation season.

7. Analysis of farm practices on nearby fields, including nutrient and pesticide applications and irrigation practices.

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Appendix A. Analytical Results

Site M-1

ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M1-1	11001	07/12/2000	363.00	15.00	6.66	718.00	7.92	0.22	0.24
M1-2	11002	07/12/2000	347.00	13.90	7.01	684.00	5.34	0.20	0.20
M1-3	11003	07/12/2000	331.00	14.30	6.63	657.00	4.24	0.18	0.18
M1-4	11004	07/12/2000	287.00	17.60	6.78	572.00	5.53	0.32	0.34
M1-5	11005	07/12/2000	275.00	15.40	6.75	549.00	5.19	0.06	0.06
M1-6	11006	07/12/2000	350.00	13.80	6.74	696.00	4.76	0.13	0.13
M1-7	11007	07/12/2000	350.00	17.00	7.06	687.00	1.44	0.24	0.43
M1-8	11008	7/12/00	323.00	16.10	7.67	636.00	0.02	0.16	0.17
M1-9	11009	7/12/00	296.00	14.40	7.03	582.00	3.55	0.15	0.22
M1-10	110010	07/12/2000	292.00	13.90	6.35	572.00	3.39	0.14	0.41
M1-11	110011	07/12/2000	233.00	17.00	7.39	455.00	2.95	1.14	1.86
M1-12	110012	07/12/2000	369.00	16.20	6.95	723.00	9.94	0.79	1.00
M1-13	110013	07/12/2000	68.00	15.90	7.21	133.00	0.02	0.13	0.19
M1-SW	110014	07/12/2000	NM	NM	NM	NM	3.82	0.32	0.32
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M1-1	21001	08/17/2000	333.00	15.10	7.16	662.00	7.30	0.24	0.24
M1-2	21002	08/17/2000	324.00	14.70	7.26	647.00	5.79	0.19	0.19
M1-3	21003	08/17/2000	304.00	14.80	7.32	608.00	4.50	0.16	0.16
M1-4	21004	08/17/2000	280.00	17.60	6.98	561.00	7.86	0.34	0.34
M1-5	21005	08/17/2000	309.00	15.40	7.33	616.00	4.40	0.06	0.06
M1-6	21006	08/17/2000	320.00	13.40	7.25	640.00	5.15	0.13	0.14
M1-7	21007	08/17/2000	302.00	15.20	7.61	604.00	0.92	0.38	0.41
M1-8	21008	08/17/2000	NM	NM	NM	NM	0.42	0.13	0.35
M1-9	21009	08/17/2000	272.00	13.70	7.27	545.00	3.33	0.29	0.31
M1-10	210010	08/17/2000	271.00	12.70	7.33	542.00	3.57	0.13	0.13
M1-11	210011	08/17/2000	205.00	17.80	7.62	411.00	2.47	1.04	1.06
M1-12	210012	08/17/2000	291.00	16.00	7.38	581.00	7.01	0.65	0.70
M1-13	210013	08/17/2000	64.00	14.90	7.93	128.00	0.47	0.05	0.05
M1-SW	210014	08/17/2000	NM	NM	NM	NM	3.19	0.28	0.28
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M1-1	31001	09/20/2000	347.00	15.80	7.50	695.00	7.57	0.24	0.24
M1-2	31002	09/20/2000	313.00	15.00	7.26	629.00	5.76	0.19	0.19
M1-3	31003	09/20/2000	300.00	15.10	7.32	600.00	4.57	0.16	0.16
M1-4	31004	09/20/2000	274.00	17.60	7.09	551.00	4.17	0.35	0.35
M1-5	31005	09/20/2000	318.00	15.60	7.40	638.00	6.70	0.06	0.06
M1-6	31006	09/20/2000	317.00	13.30	NM	635.00	5.63	0.13	0.13
M1-7	31007	09/20/2000	288.00	15.60	7.56	579.00	0.19	0.41	0.79
M1-8	31008	09/20/2000	NM	NM	NM	NM	0.09	0.14	0.34
M1-9	31009	09/20/2000	275.00	13.00	7.23	552.00	4.09	0.15	0.18
M1-10	310010	09/20/2000	269.00	12.80	7.23	542.00	3.55	0.13	0.17
M1-11	310011	09/20/2000	270.00	18.20	7.62	541.00	4.54	0.94	0.95
M1-12	310012	09/20/2000	275.00	17.00	7.40	551.00	4.19	0.65	0.83
M1-13	310013	09/20/2000	63.00	14.40	8.04	126.00	0.46	0.05	0.05
M1-SW	310014	09/20/2000	NM	NM	NM	NM	3.01	0.20	0.27

Site M-1 continued.

ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M1-1	41001	10/25/2000	347.00	15.70	6.78	694.00	5.92	0.23	0.23
M1-2	41002	10/25/2000	318.00	14.50	6.87	637.00	5.46	0.20	0.20
M1-3	41003	10/25/2000	310.00	14.50	6.85	620.00	4.13	0.17	0.17
M1-4	41004	10/25/2000	362.00	15.70	6.68	723.00	11.30	0.34	0.34
M1-5	41005	10/25/2000	356.00	14.90	6.64	715.00	7.08	0.08	0.08
M1-6	41006	10/25/2000	331.00	13.70	6.86	661.00	4.95	0.13	0.14
M1-7	41007	10/25/2000	308.00	12.80	7.42	631.00	1.05	0.48	0.55
M1-8	41008	10/25/2000	NM	NM	NM	NM	0.27	0.13	0.94
M1-9	41009	10/25/2000	262.00	12.30	7.12	516.00	3.12	0.19	0.21
M1-10	410010	10/25/2000	280.00	11.40	7.01	565.00	3.26	0.16	0.20
M1-11	410011	10/25/2000	284.00	15.10	7.05	573.00	3.72	0.78	0.78
M1-12	410012	10/25/2000	248.00	14.50	6.61	502.00	4.02	0.59	0.63
M1-13	410013	10/25/2000	67.20	13.80	7.42	134.60	0.43	0.06	0.07
M1-SW	410014	10/25/2000	NM	NM	NM	NM	3.01	0.18	0.18
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M1-1	51001	11/21/2000	334.00	14.70	7.15	668.00	5.88	0.22	0.23
M1-2	51002	11/21/2000	311.00	13.80	7.23	624.00	5.6	0.21	0.21
M1-3	51003	11/21/2000	297.00	13.80	7.28	594.00	4.41	0.17	0.17
M1-4	51004	11/21/2000	357.00	13.50	7.02	714.00	11.3	0.35	0.35
M1-5	51005	11/21/2000	342.00	14.10	7.18	685.00	6.27	0.08	0.08
M1-6	51006	11/21/2000	323.00	12.90	7.24	649.00	5.18	0.15	0.15
M1-7	51007	11/21/2000	NM	NM	NM	NM	2.37	0.47	0.47
M1-8	51008	11/21/2000	NM	NM	NM	NM	ND	0.11	0.46
M1-9	51009	11/21/2000	286.00	13.20	7.16	577.00	3.83	0.24	0.24
M1-10	510010	11/21/2000	278.00	12.80	7.16	559.00	3.43	0.17	0.18
M1-11	510011	11/21/2000	288.00	15.30	7.46	586.00	4.04	0.77	0.77
M1-12	510012	11/21/2000	300.00	14.70	7.23	603.00	3.77	0.61	0.61
M1-13	510013	11/21/2000	64.00	13.90	7.86	129.00	0.44	0.07	0.07
M1-SW	510014	11/21/00	NM	NM	NM	NM	5.06	0.19	0.20
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M1-1	61001	12/19/2000	334.00	13.60	7.27	670.00	5.79	0.20	0.24
M1-2	61002	12/19/2000	308.00	12.70	7.38	620.00	5.53	0.21	0.21
M1-3	61003	12/19/2000	295.00	12.40	7.40	590.00	4.52	0.13	0.18
M1-4	61004	12/19/2000	349.00	11.60	7.18	699.00	10.4	0.34	0.37
M1-5	61005	12/19/2000	336.00	13.10	7.30	677.00	6.79	0.07	0.12
M1-6	61006	12/19/2000	314.00	12.80	7.37	633.00	5.31	0.13	0.17
M1-7	61007	12/19/2000	NM	NM	NM	NM	3.2	0.38	0.49
M1-8	61008	12/19/2000	NM	NM	NM	NM	5.12	0.17	0.23
M1-9	61009	12/19/2000	285.00	12.60	7.29	572.00	4	0.23	0.26
M1-10	610010	12/19/2000	272.00	12.70	7.27	546.00	3.55	0.16	0.22
M1-11	610011	12/19/2000	278.00	13.60	7.61	561.00	3.75	0.70	0.61
M1-12	610012	12/19/2000	297.00	13.00	7.38	594.00	3.34	0.55	0.08
M1-13	610013	12/19/2000	63.00	14.00	8.03	126.00	0.48	0.05	0.08
M1-SW	610014	12/19/2000	NM	NM	NM	NM	0.34	0.11	0.22

Site M-1 continued.

ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M1-1	71011	01/23/2001	353.00	11.90	7.16	707.00	5.57	0.21	0.21
M1-2	71012	01/23/2001	330.00	11.10	7.23	662.00	5.37	0.20	0.2
M1-3	71013	01/23/2001	313.00	10.70	7.27	627.00	4.53	0.17	0.17
M1-4	71014	01/23/2001	375.00	9.20	7.08	750.00	12.9	0.35	0.35
M1-5	71015	01/23/2001	356.00	11.40	7.16	713.00	7.67	0.09	0.09
M1-6	71016	01/23/2001	331.00	12.70	7.24	666.00	5.27	0.14	0.14
M1-7	71017	01/23/2001	NM	NM	NM	NM	3.48	0.35	0.37
M1-8	71018	01/23/2001	NM	NM	NM	NM	ND	0.12	0.25
M1-9	71019	01/23/2001	301.00	11.90	7.19	602.00	3.95	0.24	0.25
M1-10	710110	01/23/2001	285.00	12.50	7.18	571.00	3.62	0.17	0.26
M1-11	710111	01/23/2001	260.00	12.10	7.47	525.00	3.74	0.62	0.62
M1-12	710112	01/23/2001	324.00	10.80	7.27	651.00	5.16	0.57	0.57
M1-13	710113	01/23/2001	65.00	13.70	7.79	131.00	0.52	0.06	0.06
M1-SW	710114	01/23/2001	NM	NM	NM	NM	4.62	0.17	0.26
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M1-1	81011	02/27/2001	352.00	11.50	7.23	698.00	5.95	0.22	0.24
M1-2	81012	02/27/2001	330.00	10.40	7.32	660.00	5.66	0.2	0.23
M1-3	81013	02/27/2001	315.00	9.90	7.35	629.00	4.8	0.17	0.2
M1-4	81014	02/27/2001	366.00	8.50	7.15	728.00	10.44	0.38	0.38
M1-5	81015	02/27/2001	356.00	11.10	7.23	709.00	8.81	0.11	0.13
M1-6	81016	02/27/2001	333.00	13.10	7.31	664.00	5.51	0.15	0.17
M1-7	81017	02/27/2001	NM	NM	NM	NM	3.86	0.34	0.44
M1-8	81018	02/27/2001	NM	NM	NM	NM	<0.20	0.13	0.34
M1-9	81019	02/27/2001	301.00	11.40	7.25	603.00	4.41	0.25	0.25
M1-10	810110	02/27/2001	283.00	12.40	7.23	567.00	3.66	0.19	0.22
M1-11	810111	02/27/2001	272.00	11.40	7.51	544.00	4.15	0.61	0.66
M1-12	810112	02/27/2001	344.00	9.10	7.31	690.00	8.4	0.55	0.62
M1-13	810113	02/27/2001	66.00	14.10	7.86	131.00	0.5	0.07	0.08
M1-SW	810114	02/27/2001	NM	NM	NM	NM	4.92	0.18	0.28
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M1-1	91011	03/26/2001	333.00	11.30	7.18	666.00	5.74	0.19	0.19
M1-2	91012	03/26/2001	321.00	10.60	7.25	639.00	5.54	0.25	0.25
M1-3	91013	03/26/2001	303.00	10.10	7.28	604.00	4.81	0.13	0.18
M1-4	91014	03/26/2001	349.00	9.00	7.09	698.00	11	0.34	0.37
M1-5	91015	03/26/2001	340.00	10.60	7.16	678.00	9.42	0.10	0.11
M1-6	91016	03/26/2001	317.00	13.50	7.26	632.00	5..19	0.13	0.15
M1-7	91017	03/26/2001	NM	NM	NM	NM	4.34	0.29	0.38
M1-8	91018	03/26/2001	NM	NM	NM	NM	0.24	0.11	0.16
M1-9	91019	03/26/2001	287.00	11.20	7.20	575.00	4.12	0.16	0.25
M1-10	910110	03/26/2001	269.00	12.60	7.19	539.00	3.43	0.22	0.23
M1-11	910111	03/26/2001	256.00	11.70	7.47	511.00	3.82	0.54	0.55
M1-12	910112	03/26/2001	337.00	9.40	7.33	676.00	10.3	0.58	0.59
M1-13	910113	03/26/2001	63.00	14.60	7.84	125.00	0.49	0.06	0.08
M1-SW	910114	3/26/01	NM	NM	NM	NM	4.16	0.18	0.19

Site M-1 continued.

ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M1-1	101011	4/20/01	341	10.9	7.17	680	5.41	0.22	0.24
M1-2	101012	4/20/01	335	10.2	7.22	668	5.77	0.19	0.22
M1-3	101013	4/20/01	306	10	7.24	612	5.21	0.18	0.23
M1-4	101014	4/20/01	345	9.6	7.06	688	9.12	0.37	0.4
M1-5	101015	4/20/01	346	10.6	7.11	693	11.6	0.12	0.15
M1-6	101016	04/20/01	320	12.80	7.24	642	5.26	0.15	0.18
M1-7	101017	4/20/01	NM	NM	NM	NM	3.36	0.3	0.36
M1-8	101018	4/20/01	NM	NM	NM	NM	<0.20	0.14	0.76
M1-9	101019	4/20/01	287	10.9	7.15	577	3.94	0.25	0.28
M1-10	1010110	4/20/01	271	12.1	7.14	542	3.59	0.19	0.22
M1-11	1010111	4/20/01	280	11	7.43	564	4.26	0.5	0.51
M1-12	1010112	4/20/01	350	9.2	7.28	700	12.6	0.54	0.58
M1-13	1010113	4/20/01	62	13.9	7.79	126	0.46	0.07	0.08
M1-SW	1010114	4/20/01	NM	NM	NM	NM	2.48	0.18	0.36
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M1-1	111011	5/21/01	402	13	7.04	792	6.18	NM	0.17
M1-2	111012	5/21/01	433	10.8	6.98	867.00	6.93	NM	0.17
M1-3	111013	5/21/01	436.00	10.90	7.05	872	4.98	NM	0.13
M1-4	111014	5/21/01	335	13	6.96	672	2.37	NM	0.31
M1-5	111015	5/21/01	363	12.9	6.97	722	3.89	NM	0.2
M1-6	111016	05/21/01	405	13.80	7.17	805	4.67	NM	0.11
M1-7	111017	5/21/01	NM	NM	NM	NM	2.38	NM	0.33
M1-8	111018	5/21/01	NM	NM	NM	NM	0.53	NM	0.22
M1-9	111019	5/21/01	336	11.8	7.19	670	4.02	NM	0.18
M1-10	1110110	5/21/01	326	12.2	7.17	655	3.6	NM	0.21
M1-11	1110111	5/21/01	343	11.4	7.35	685	3.88	NM	0.65
M1-12	1110112	5/21/01	407	10.7	7.25	812	10.1	NM	0.74
M1-13	1110113	5/21/01	84	14.2	7.6	166.5	0.48	NM	<0.05
M1-SW	1110114	5/21/01	NM	NM	NM	NM	2.59	NM	0.45
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M1-1	121011	6/18/01	329	12.8	7.07	652	5.81	0.16	0.21
M1-2	121012	6/18/01	322.00	12.80	7.11	640	5.73	0.14	0.17
M1-3	121013	6/18/01	340	12.6	7.11	677	4.50	0.12	0.12
M1-4	121014	6/18/01	226	14.8	7	451	2.80	0.25	0.34
M1-5	121015	6/18/01	260	13.3	7.03	519	4.46	0.13	0.15
M1-6	121016	06/18/01	333	13.5	7.20	664	4.57	0.10	0.10
M1-7	121017	6/18/01	NM	NM	NM	NM	<0.20	0.28	0.4
M1-8	121018	6/18/01	NM	NM	NM	NM	0.43	0.09	0.21
M1-9	121019	6/18/01	271	12.2	7.06	541	3.82	0.19	0.22
M1-10	1210110	6/18/01	265	12.4	7.06	530	3.08	0.14	0.17
M1-11	1210111	6/18/01	270	13.1	7.34	539	3.35	0.45	0.62
M1-12	1210112	6/18/01	307	12	7.18	613	3.57	0.45	0.64
M1-13	1210113	6/18/01	62	14.8	7.65	125	<0.20	<0.05	<0.05
M1-SW	1210114	6/18/01	NM	NM	NM	NM	3.23	0.20	0.36

Site M-1 continued.

ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M1-1	131011	7/16/01	351	13.4	7.15	703	5.58	0.20	0.24
M1-2	131012	7/16/01	334	13.5	7.18	667.00	5.26	0.18	0.22
M1-3	131013	7/16/01	355	13.4	7.17	709	4.70	0.14	0.14
M1-4	131014	7/16/01	312	16.9	7	622	7.79	0.34	0.36
M1-5	131015	7/16/01	346	14.1	6.99	691	8.17	0.16	0.43
M1-6	131016	07/16/01	354	13.2	7.27	706	4.42	0.12	0.16
M1-7	131017	7/16/01	NM	NM	NM	NM	2.25	0.40	0.44
M1-8	131018	7/16/01	NM	NM	NM	NM	0.37	0.15	0.23
M1-9	131019	7/16/01	287	12.6	7.09	574	3.36	0.16	0.17
M1-10	1310110	7/16/01	283	12.6	7.12	565	3.24	0.18	0.18
M1-11	1310111	7/16/01	253	14.3	7.42	506	2.56	0.63	0.84
M1-12	1310112	7/16/01	324	13.7	7.2	648	4.18	0.62	0.62
M1-13	1310113	7/16/01	66	14.5	7.73	131	0.43	<0.05	<0.05
M1-SW	1310114	7/16/01	NM	NM	NM	NM	3.06	0.30	0.44
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M1-1	141011	8/27/01	357	15.7	NM	713	3.51	0.17	0.18
M1-2	141012	8/27/01	341	14.9	NM	681.00	3.90	0.14	0.16
M1-3	141013	8/27/01	362	15.2	NM	726	5.61	0.17	0.17
M1-4	141014	8/27/01	302	18.9	NM	603	5.31	0.35	0.35
M1-5	141015	8/27/01	353	16.3	NM	703	2.69	0.65	0.66
M1-6	141016	08/27/01	349	13.9	NM	698	6.93	0.62	0.67
M1-7	141017	8/27/01	NM	NM	NM	NM	5.03	0.12	0.14
M1-8	141018	8/27/01	NM	NM	NM	NM	3.75	0.27	0.33
M1-9	141019	8/27/01	287	13.6	NM	572	4.06	0.15	0.16
M1-10	1410110	8/27/01	286	13.4	NM	571	5.8	0.19	0.19
M1-11	1410111	8/27/01	278	17.5	NM	557	4.23	0.15	0.15
M1-12	1410112	8/27/01	313	16.7	NM	626	4.99	0.12	0.12
M1-13	1410113	8/27/01	65	14.8	NM	130	0.44	<0.05	<0.05
M1-SW	1410114	8/27/01	NM	NM	NM	NM	0.3	0.14	1.17
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M1-1	151011	9/11/01	363	15.1	NM	724	5.57	0.18	0.18
M1-2	151012	9/11/01	355	15	NM	710.00	6.55	0.16	0.16
M1-3	151013	9/11/01	351	14.9	NM	702	4.03	0.17	0.17
M1-4	151014	9/11/01	308	18.3	NM	616	3.20	0.34	0.36
M1-5	151015	9/11/01	352	15.5	NM	701	3.97	0.15	0.15
M1-6	151016	09/11/01	351	13.7	NM	702	5.17	0.13	0.13
M1-7	151017	9/11/01	NM	NM	NM	NM	3.15	0.45	0.75
M1-8	151018	9/11/01	NM	NM	NM	NM	0.52	0.1	2.6
M1-9	151019	9/11/01	291	13.1	NM	582	4.07	0.2	0.23
M1-10	1510110	9/11/01	287	12.4	NM	574	3.42	0.19	0.21
M1-11	1510111	9/11/01	277	17.1	NM	552	2.44	0.67	0.67
M1-12	1510112	9/11/01	315	16.8	NM	627	6.24	0.64	0.65
M1-13	1510113	9/11/01	66.8	14	NM	133.3	0.49	<0.05	0.06
M1-SW	1510114	9/11/01	NM	NM	NM	NM	4.02	0.25	0.26

Site M-1 continued.

ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M1-1	161011	10/22/01	337	15.4	7.18	672	5.41	0.17	0.19
M1-2	161012	10/22/01	313	14.3	7.17	625.00	5.46	0.17	0.17
M1-3	161013	10/22/01	324	14.8	7.17	648	6.02	0.13	0.13
M1-4	161014	10/22/01	331	15.7	6.95	662	8.11	0.32	0.35
M1-5	161015	10/22/01	360	14.8	7.14	720	5.03	0.1	0.12
M1-6	161016	10/22/01	322	13.0	7.21	645	5.65	0.11	0.11
M1-7	161017	10/22/01	NM	NM	NM	NM	1.65	0.43	0.54
M1-8	161018	10/22/01	NM	NM	NM	NM	0.37	0.14	0.25
M1-9	161019	10/22/01	277	13.1	6.97	553	3.71	0.18	0.19
M1-10	1610110	10/22/01	272	12.6	7.11	543	3.46	0.16	0.19
M1-11	1610111	10/22/01	282	16.4	7.34	566	3.96	0.54	0.6
M1-12	1610112	10/22/01	295	16.6	7.22	593	4.46	0.57	0.66
M1-13	1610113	10/22/01	62	14.1	7.63	125	0.41	<0.05	<0.05
M1-14	1610114	10/22/01	NM	NM	NM	NM	4.94	0.15	0.19
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M1-1	171011	11/19/01	335	14.3	7.25	673	5.03	0.19	0.21
M1-2	171012	11/19/01	314	13.4	7.32	631.00	5.24	0.19	0.20
M1-3	171013	11/19/01	314	13.8	7.31	628	4.29	0.13	0.13
M1-4	171014	11/19/01	347	13.8	7.09	695	7.55	0.38	0.41
M1-5	171015	11/19/01	361	14.0	7.29	723	4.92	0.08	0.08
M1-6	171016	11/19/01	321	12.8	7.31	644	5.55	0.13	0.14
M1-7	171017	11/19/01	NM	NM	NM	NM	1.97	0.45	0.52
M1-8	171018	11/19/01	NM	NM	NM	NM	0.52	0.09	0.09
M1-9	171019	11/19/01	280	12.8	7.28	562	3.64	0.22	0.22
M1-10	1710110	11/19/01	274	12.2	7.26	550	3.31	0.18	0.19
M1-11	1710111	11/19/01	308	15.1	7.46	617	3.1	0.59	0.61
M1-12	1710112	11/19/01	293	15.1	7.31	588	3.1	0.61	0.61
M1-13	1710113	11/19/01	63	13.6	7.85	125	0.41	<0.05	<0.05
M1-14	1710114	11/19/01	NM	NM	NM	NM	4.75	0.19	0.21
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M1-1	181011	12/26/01	NM	NM	NM	NM	5.15	0.21	0.3
M1-2	181012	12/26/01	NM	NM	NM	NM	5.47	0.20	0.21
M1-3	181013	12/26/01	NM	NM	NM	NM	4.52	0.14	0.14
M1-4	181014	12/26/01	NM	NM	NM	NM	17.00	0.38	0.39
M1-5	181015	12/26/01	NM	NM	NM	NM	6.1	0.13	0.14
M1-6	181016	12/26/01	NM	NM	NM	NM	5.75	0.09	0.14
M1-7	181017	12/26/01	NM	NM	NM	NM	3.37	0.44	0.51
M1-8	181018	12/26/01	NM	NM	NM	NM	0.92	0.13	0.17
M1-9	181019	12/26/01	NM	NM	NM	NM	3.82	0.23	0.27
M1-10	1810110	12/26/01	NM	NM	NM	NM	3.56	0.19	0.24
M1-11	1810111	12/26/01	NM	NM	NM	NM	2.8	0.6	0.68
M1-12	1810112	12/26/01	NM	NM	NM	NM	4.35	0.59	0.61
M1-13	1810113	12/26/01	NM	NM	NM	NM	0.44	<0.05	0.06
M1-14	1810114	12/26/01	NM	NM	NM	NM	4.78	0.18	0.32

Site M-3

ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M3-1	13001	07/20/2000	375.00	14.30	7.23	749.00	10.40	0.30	0.30
M3-2	13002	07/20/2000	411.00	13.80	7.18	818.00	11.10	0.31	0.31
M3-3	13003	07/20/2000	434.00	13.50	7.12	865.00	11.60	0.38	0.38
M3-4	13004	07/20/2000	350.00	13.50	7.24	699.00	4.48	0.09	0.09
M3-5	13005	07/20/2000	80.00	13.60	7.52	160.00	0.85	0.06	0.06
M3-6	13006	07/20/2000	400.00	13.80	7.32	796.00	10.80	0.31	0.31
M3-7	13007	07/20/2000	412.00	12.20	7.27	820.00	12.00	0.29	0.29
M3-8	13008	07/20/2000	249.00	12.70	7.32	497.00	14.40	0.19	0.19
M3-9	13009	07/20/2000	355.00	14.50	7.18	709.00	5.02	0.32	0.36
M3-10	130010	07/20/2000	289.00	13.20	7.10	578.00	4.14	0.37	0.39
M3-11	130011	07/20/2000	362.00	15.90	7.19	722.00	6.39	0.45	0.46
M3-12	130012	07/20/2000	349.00	14.30	7.16	697.00	7.77	0.35	0.40
M3-13	130013	07/20/2000	345.00	12.60	7.15	686.00	6.13	0.25	0.27
M3-14	130014	07/20/2000	356.00	12.60	7.30	709.00	7.87	0.22	0.26
M3-SW	NM	NM	NM	NM	NM	NM	NM	NM	NM
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M3-1	23001	08/24/2000	314.00	15.00	7.39	625.00	7.44	0.31	0.31
M3-2	23002	08/24/2000	370.00	14.30	7.34	740.00	11.10	0.34	0.34
M3-3	23003	08/24/2000	399.00	14.00	7.20	796.00	11.00	0.33	0.34
M3-4	23004	08/24/2000	327.00	13.40	7.40	653.00	4.64	0.05	0.05
M3-5	23005	08/24/2000	91.00	13.80	7.69	177.00	0.88	0.05	0.05
M3-6	23006	08/24/2000	368.00	14.20	7.38	734.00	9.35	0.29	0.29
M3-7	23007	08/24/2000	381.00	12.80	7.31	756.00	12.40	0.27	0.27
M3-8	23008	08/24/2000	385.00	13.00	7.43	765.00	13.90	0.17	0.17
M3-9	23009	08/24/2000	319.00	16.30	7.21	638.00	4.99	0.40	0.40
M3-10	230010	08/24/2000	295.00	13.70	7.18	590.00	6.36	0.38	0.38
M3-11	230011	08/24/2000	327.00	17.80	7.29	653.00	5.71	0.45	0.45
M3-12	230012	08/24/2000	328.00	14.20	7.24	657.00	8.03	0.37	0.37
M3-13	230013	08/24/2000	327.00	12.80	7.15	652.00	7.25	0.24	0.24
M3-14	230014	08/24/2000	332.00	12.90	7.30	663.00	8.03	0.19	0.19
M3-SW	230015	08/24/2000	NM	NM	NM	NM	2.56	0.18	0.20
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M3-1	33001	09/27/2000	307.00	14.30	7.29	614.00	6.24	0.33	0.33
M3-2	33002	09/27/2000	386.00	14.00	7.27	771.00	12.50	0.36	0.36
M3-3	33003	09/27/2000	405.00	13.80	7.11	809.00	11.80	0.35	0.35
M3-4	33004	09/27/2000	329.00	12.90	7.28	659.00	4.47	0.07	0.07
M3-5	33005	09/27/2000	73.00	13.40	7.78	147.00	0.59	0.05	0.05
M3-6	33006	09/27/2000	374.00	14.20	7.28	748.00	11.60	0.33	0.33
M3-7	33007	09/27/2000	385.00	12.30	7.23	770.00	12.00	0.27	0.27
M3-8	33008	09/27/2000	385.00	12.40	7.29	771.00	13.50	0.17	0.17
M3-9	33009	09/27/2000	320.00	15.40	7.31	644.00	4.82	0.42	0.42
M3-10	330010	09/27/2000	309.00	13.30	7.11	621.00	7.32	0.38	0.38
M3-11	330011	09/27/2000	324.00	16.60	7.23	650.00	5.22	0.46	0.46
M3-12	330012	09/27/2000	332.00	12.90	7.27	666.00	7.87	0.39	0.39
M3-13	330013	09/27/2000	332.00	12.10	7.13	666.00	7.21	0.26	0.26
M3-14	330014	09/27/2000	335.00	12.00	7.33	671.00	8.02	0.19	0.19
M3-SW	330015	09/27/2000	NM	NM	NM	NM	2.19	0.18	0.19

Site M-3 continued.

ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M3-1	43001	10/26/2000	306.00	12.50	6.85	614.00	6.31	0.31	0.34
M3-2	43002	10/26/2000	386.00	11.80	7.18	783.00	10.90	0.36	0.36
M3-3	43003	10/26/2000	419.00	12.20	7.06	846.00	12.70	0.33	0.36
M3-4	43004	10/26/2000	337.00	11.40	7.19	681.00	4.34	0.08	0.11
M3-5	43005	10/26/2000	75.90	12.20	7.67	151.40	0.55	0.06	0.07
M3-6	43006	10/26/2000	394.00	12.50	7.12	785.00	10.90	0.30	0.32
M3-7	43007	10/26/2000	399.00	11.10	7.01	804.00	12.30	0.29	0.29
M3-8	43008	10/26/2000	397.00	11.20	6.98	801.00	12.80	0.15	0.20
M3-9	43009	10/26/2000	342.00	14.40	7.01	686.00	3.45	0.41	0.41
M3-10	430010	10/26/2000	324.00	12.70	7.00	648.00	7.52	0.38	0.40
M3-11	430011	10/26/2000	332.00	13.60	6.87	673.00	5.01	0.42	0.42
M3-12	430012	10/26/2000	345.00	12.00	7.74	692.00	7.69	0.36	0.37
M3-13	430013	10/26/2000	340.00	11.40	7.48	685.00	7.14	0.27	0.28
M3-14	430014	10/26/2000	343.00	11.40	7.77	689.00	7.55	0.18	0.19
M3-SW	430015	10/26/2000	NM	NM	NM	NM	3.75	0.16	0.19
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M3-1	53001	11/22/2000	326.00	11.30	7.47	652.00	7.80	0.32	0.34
M3-2	53002	11/22/2000	371.00	11.10	7.41	745.00	10.4	0.36	0.38
M3-3	53003	11/22/2000	408.00	11.90	7.29	818.00	14.9	0.36	0.38
M3-4	53004	11/22/2000	342.00	12.60	7.44	684.00	5.12	ND	0.10
M3-5	53005	11/22/2000	71.00	12.70	7.87	142.00	0.58	0.07	0.07
M3-6	53006	11/22/2000	378.00	11.40	7.40	755.00	11.8	0.31	0.31
M3-7	53007	11/22/2000	387.00	12.10	7.38	772.00	13.2	0.28	0.28
M3-8	53008	11/22/2000	397.00	12.20	7.44	795.00	15.0	0.17	0.18
M3-9	53009	11/22/2000	343.00	12.80	7.35	691.00	3.12	0.37	0.39
M3-10	530010	11/22/2000	321.00	11.60	7.16	647.00	7.59	0.36	0.39
M3-11	530011	11/22/2000	327.00	12.50	7.39	656.00	5.05	0.43	0.50
M3-12	530012	11/22/2000	336.00	10.70	7.40	675.00	7.82	0.35	0.36
M3-13	530013	11/22/2000	332.00	11.60	7.21	671.00	7.28	0.31	0.32
M3-14	530014	11/22/2000	337.00	11.80	7.41	676.00	7.90	0.19	0.19
M3-SW	530015	11/22/2000	NM	NM	NM	NM	4.58	0.18	0.19
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M3-1	63001	12/20/00	334.00	9.10	7.43	670.00	9.33	0.31	0.33
M3-2	63002	12/20/00	374.00	9.10	7.39	749.00	10.80	0.35	0.37
M3-3	63003	12/20/00	410.00	9.90	7.28	822.00	14.40	0.34	0.37
M3-4	63004	12/20/00	334.00	12.10	7.44	670.00	4.94	0.08	0.11
M3-5	63005	12/20/00	73.00	12.70	7.82	146.00	0.58	0.06	0.09
M3-6	63006	12/20/00	375.00	9.50	7.36	751.00	12.00	0.30	0.33
M3-7	63007	12/20/00	386.00	11.60	7.36	778.00	13.30	0.29	0.34
M3-8	63008	12/20/00	387.00	11.90	7.40	779.00	14.40	0.16	0.18
M3-9	63009	12/20/00	329.00	10.80	7.35	661.00	3.50	0.34	0.37
M3-10	630010	12/20/00	318.00	10.50	7.17	637.00	8.00	0.36	0.40
M3-11	630011	12/20/00	325.00	10.40	7.40	652.00	5.35	0.42	0.44
M3-12	630012	12/20/00	335.00	9.30	7.37	673.00	8.33	0.34	0.38
M3-13	630013	12/20/00	332.00	11.00	7.17	665.00	7.66	0.29	0.31
M3-14	630014	12/20/00	336.00	11.80	7.38	675.00	8.42	0.18	0.21
M3-SW	630015	12/20/00	NM	NM	NM	NM	0.34	0.11	0.22

Site M-3 continued.

ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M3-1	73011	01/24/2001	360.00	7.50	7.41	720.00	9.88	0.29	0.31
M3-2	73012	01/24/2001	399.00	7.20	7.37	798.00	11.3	0.32	0.32
M3-3	73013	01/24/2001	430.00	8.30	7.29	861.00	13.9	0.33	0.34
M3-4	73014	01/24/2001	354.00	11.80	7.40	710.00	4.94	0.10	0.10
M3-5	73015	01/24/2001	75.00	12.20	7.78	150.00	0.65	0.07	0.08
M3-6	73016	01/24/2001	392.00	8.10	7.36	786.00	12	0.29	0.33
M3-7	73017	01/24/2001	410.00	10.90	7.35	819.00	13.4	0.20	0.30
M3-8	73018	01/24/2001	409.00	11.50	7.37	819.00	14.5	0.15	0.15
M3-9	73019	01/24/2001	350.00	8.50	7.33	701.00	3.32	0.32	0.33
M3-10	730110	01/24/2001	330.00	8.70	7.15	659.00	7.42	0.35	0.37
M3-11	730111	01/24/2001	349.00	8.50	7.40	698.00	5.51	0.40	0.42
M3-12	730112	01/24/2001	354.00	8.00	7.38	710.00	8.18	0.33	0.34
M3-13	730113	01/24/2001	350.00	10.10	7.19	701.00	7.87	0.27	0.27
M3-14	730114	01/24/2001	355.00	11.50	7.37	712.00	8.33	0.19	0.19
M3-SW	730115	01/24/2001	NM	NM	NM	NM	4.17	0.16	0.29
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M3-1	83011	02/28/2001	363.00	6.40	7.36	728.00	10.3	0.29	0.29
M3-2	83012	02/28/2001	399.00	6.80	7.41	800.00	11.2	0.28	0.34
M3-3	83013	02/28/2001	427.00	7.70	7.31	854.00	13.5	0.33	0.33
M3-4	83014	02/28/2001	355.00	11.70	7.39	713.00	5.34	0.09	0.09
M3-5	83015	02/28/2001	76.00	13.10	7.83	152.00	0.64	0.07	0.08
M3-6	83016	02/28/2001	391.00	7.40	7.37	780.00	12.5	0.30	0.30
M3-7	83017	02/28/2001	410.00	10.70	7.35	820.00	13.6	0.28	0.28
M3-8	83018	02/28/2001	409.00	11.50	7.38	820.00	14.6	0.15	0.15
M3-9	83019	02/28/2001	371.00	8.10	7.39	740.00	3.35	0.32	0.32
M3-10	830110	02/28/2001	332.00	8.40	7.22	663.00	7.42	0.36	0.36
M3-11	830111	02/28/2001	353.00	7.60	7.46	708.00	5.86	0.41	0.41
M3-12	830112	02/28/2001	354.00	8.00	7.42	709.00	8.30	0.35	0.35
M3-13	830113	02/28/2001	350.00	10.10	7.23	700.00	7.84	0.27	0.27
M3-14	830114	02/28/2001	356.00	12.00	7.41	712.00	8.47	0.20	0.20
M3-SW	830115	02/28/2001	NM	NM	NM	NM	4.00	0.16	0.28
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M3-1	93011	03/27/2001	345.00	7.90	7.33	690.00	10.1	0.28	0.29
M3-2	93012	03/27/2001	378.00	7.70	7.31	756.00	11.1	0.31	0.32
M3-3	93013	03/27/2001	402.00	8.30	7.27	804.00	12.2	0.32	0.33
M3-4	93014	03/27/2001	335.00	12.40	7.35	671.00	5.09	0.09	0.24
M3-5	93015	03/27/2001	73.00	13.10	7.72	147.00	0.66	0.07	0.08
M3-6	93016	03/27/2001	370.00	8.40	7.29	733.00	12	0.28	0.29
M3-7	93017	03/27/2001	386.00	11.10	7.28	770.00	13.1	0.27	0.28
M3-8	93018	03/27/2001	385.00	12.20	7.31	768.00	13.9	0.13	0.16
M3-9	93019	03/27/2001	340.00	7.90	7.25	680.00	4.5	0.30	0.31
M3-10	930110	03/27/2001	307.00	8.40	7.10	616.00	7.10	0.32	0.34
M3-11	930111	03/27/2001	337.00	8.60	7.35	671.00	5.61	0.39	0.41
M3-12	930112	03/27/2001	335.00	8.70	7.30	670.00	8.07	0.33	0.34
M3-13	930113	03/27/2001	330.00	10.00	7.12	659.00	7.64	0.26	NA
M3-14	930114	03/27/2001	337.00	12.00	7.32	674.00	8.17	0.19	0.20
M3-SW	930115	03/27/2001	NM	NM	NM	NM	3.53	0.14	0.18

Site M-3 continued.

ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M3-1	103011	4/19/01	346	8.3	7.23	694	10.9	0.3	0.32
M3-2	103012	4/19/01	380	8.4	7.21	756	12.1	0.33	0.35
M3-3	103013	4/19/01	401	8.6	7.16	802	13.1	0.33	0.35
M3-4	103014	4/19/01	336.00	11.40	7.25	679.00	5.58	0.09	0.09
M3-5	103015	4/19/01	74	11.6	7.84	149	0.66	0.08	0.08
M3-6	103016	4/19/01	371	8.7	7.18	740	12.9	0.3	0.3
M3-7	103017	4/19/01	386	10.6	7.2	774	13.8	0.28	0.3
M3-8	103018	4/19/01	386	11.5	7.22	774	14.6	0.14	0.16
M3-9	103019	4/19/01	344	8.7	7.3	685	5.35	0.31	0.32
M3-10	1030110	4/19/01	306	8.8	7.17	613	6.52	0.34	0.34
M3-11	1030111	4/19/01	342	8.9	7.41	683	5.90	0.41	0.41
M3-12	1030112	4/19/01	334	9.2	7.38	668	7.62	0.34	0.34
M3-13	1030113	4/19/01	330	9.9	7.2	660	7.20	0.26	0.26
M3-14	1030114	4/19/01	337	11	7.4	678	8.83	0.2	0.21
M3-SW	1030115	4/19/01	NM	NM	NM	NM	2.63	0.14	0.20
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M3-1	113011	5/24/01	338	11.3	7.22	677	11.6	0.24	0.31
M3-2	113012	5/24/01	371	10.8	7.19	745	13.2	0.24	0.32
M3-3	113013	5/21/01	400	10.4	7.15	796	14.4	0.27	0.35
M3-4	113014	5/24/01	332.00	13.10	7.26	662.00	5.56	0.06	0.07
M3-5	113015	5/24/01	73	13.6	7.62	145	0.69	<0.05	<0.05
M3-6	113016	5/24/01	348	11.1	7.23	698	11.6	0.24	0.32
M3-7	113017	5/24/01	380	11.8	7.22	762	14.6	0.17	0.27
M3-8	113018	5/24/01	383	12.9	7.28	764	15.7	0.1	0.12
M3-9	113019	5/24/01	336	11	7.13	669	6.31	0.26	0.33
M3-10	1130110	5/24/01	316	10	7.02	633	8.46	0.27	0.37
M3-11	1130111	5/24/01	299	11.5	7.17	597	5.22	0.28	0.38
M3-12	1130112	5/24/01	333	11.9	7.18	664	9.19	0.27	0.36
M3-13	1130113	5/24/01	328	11.3	7.05	655	8.62	0.21	0.26
M3-14	1130114	5/24/01	333	12.5	7.21	666	9.17	0.13	0.32
M3-SW	1130115	5/24/01	NM	NM	NM	NM	2.43	0.14	0.24
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M3-1	123011	6/21/01	461	14.9	7.1	924	22.2	0.32	0.32
M3-2	123012	6/21/01	359	13.7	7.25	718	11.9	0.39	0.41
M3-3	123013	6/21/01	384	12.9	7.22	764	12.2	0.39	0.39
M3-4	123014	6/21/01	327	13.4	7.28	657	4.56	0.08	0.08
M3-5	123015	6/21/01	78	13.5	7.53	156	0.80	0.06	0.06
M3-6	123016	6/21/01	421	13.6	7.24	837	16.7	0.36	0.72
M3-7	123017	6/21/01	381	12.3	7.27	759	13.8	0.25	0.25
M3-8	123018	6/21/01	382	13	7.3	756	14.6	0.13	0.13
M3-9	123019	6/21/01	333	13.1	7.01	666	3.66	0.38	0.40
M3-10	1230110	6/21/01	319	11.2	7.00	638	7.90	0.37	0.39
M3-11	1230111	6/21/01	295	13.4	7.19	591	3.91	0.39	0.41
M3-12	1230112	6/21/01	335	13.1	7.21	670	8.27	0.36	0.36
M3-13	1230113	6/21/01	330	11.9	7.05	660	6.40	0.31	0.31
M3-14	1230114	6/21/01	335	12.4	7.23	670	0.80	0.17	0.17
M3-SW	1230115	6/21/01	NM	NM	NM	NM	2.98	0.21	0.24

Site M-3 continued.

ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M3-1	133011	7/18/01	507	16.6	7.2	1013	24.5	0.32	0.35
M3-2	133012	7/18/01	472	15.4	7.20	942	18.1	0.36	0.37
M3-3	133013	7/18/01	414	13.7	7.27	826	13.2	0.37	0.37
M3-4	133014	7/18/01	353	13.2	7.36	705	4.81	0.07	0.09
M3-5	133015	7/18/01	110	13.6	7.48	220	1.31	0.05	0.06
M3-6	133016	7/18/01	430	15	7.24	860	15.5	0.33	0.33
M3-7	133017	7/18/01	407	12.1	7.31	814	14.1	0.26	0.29
M3-8	133018	7/18/01	408	12.8	7.34	816	15.1	0.12	0.14
M3-9	133019	7/18/01	295	18.8	7.08	592	1.48	0.35	0.38
M3-10	1330110	7/18/01	367	13.5	7.12	737	7.02	0.39	0.43
M3-11	1330111	7/18/01	313	17.2	7.26	626	3.70	0.48	0.50
M3-12	1330112	7/18/01	362	15.2	7.30	725	8.15	0.32	0.35
M3-13	1330113	7/18/01	356	12.7	7.16	711	7.60	0.32	0.35
M3-14	1330114	7/18/01	358	12.4	7.31	716	8.26	0.16	0.18
M3-SW	1330115	7/18/01	NM	NM	NM	NM	2.63	0.27	0.33
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M3-1	143011	8/28/01	438	16.6	NM	876	12.6	0.33	0.34
M3-2	143012	8/28/01	437	16.4	NM	874	12.8	0.39	0.44
M3-3	143013	8/28/01	441	14.8	NM	883	15.3	0.38	0.41
M3-4	143014	8/28/01	353	12.8	NM	707	5.29	0.07	0.07
M3-5	143015	8/28/01	82	15.3	NM	168	0.89	0.06	0.06
M3-6	143016	8/28/01	416	15.7	NM	834	13.3	0.34	0.35
M3-7	143017	8/28/01	407	12.4	NM	813	13.7	0.26	0.28
M3-8	143018	8/28/01	407	12.4	NM	815	15.4	0.12	0.13
M3-9	143019	8/28/01	266	21.1	NM	532	5.2	0.32	0.32
M3-10	1430110	8/28/01	360	15.1	NM	721	8.61	0.42	0.43
M3-11	1430111	8/28/01	379	18.8	NM	756	4.82	0.48	0.50
M3-12	1430112	8/28/01	347	18	NM	690	5.61	0.32	0.36
M3-13	1430113	8/28/01	360	17.3	NM	710	8.79	0.35	0.37
M3-14	1430114	8/28/01	356	15.2	NM	704	8.99	0.16	0.17
M3-SW	1430115	8/28/01	NM	NM	NM	NM	3.21	0.21	0.29
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M3-1	153011	9/12/01	411	17.5	NM	820	11.4	0.34	0.35
M3-2	153012	9/12/01	472	17.2	NM	944	11.9	0.41	0.45
M3-3	153013	9/12/01	462	16.4	NM	926	15.9	0.39	0.39
M3-4	153014	9/12/01	356	13.7	NM	709	5.54	0.07	0.08
M3-5	153015	9/12/01	80	13.6	NM	160	0.69	0.06	0.06
M3-6	153016	9/12/01	423	16.4	NM	848	12.5	0.34	0.36
M3-7	153017	9/12/01	410	13.5	NM	818	14.7	0.25	0.26
M3-8	153018	9/12/01	409	13.4	NM	816	15.6	0.13	0.13
M3-9	153019	9/12/01	365	19.3	NM	732	5.64	0.36	0.37
M3-10	1530110	9/12/01	356	15.2	NM	713	8.43	0.42	0.42
M3-11	1530111	9/12/01	330	17.8	NM	661	4.74	0.4	0.42
M3-12	1530112	9/12/01	361	14.5	NM	722	8.99	0.3	0.32
M3-13	1530113	9/12/01	358	13.2	NM	716	8.62	0.35	0.36
M3-14	1530114	9/12/01	362	12.9	NM	722	9.12	0.16	0.16
M3-SW	1530115	9/12/01	NM	NM	NM	NM	4.7	0.23	0.24

Site M-3 continued.

ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M3-1	163011	10/23/01	401	14.2	7.33	801	8.94	0.29	0.34
M3-2	163012	10/23/01	410	14.1	7.33	817	12.5	0.32	0.34
M3-3	163013	10/23/01	443	14	7.27	886	13.7	0.35	0.41
M3-4	163014	10/23/01	338	12.5	7.45	677	5.41	0.06	0.07
M3-5	163015	10/23/01	72	12.8	7.73	144	0.65	0.05	0.06
M3-6	163016	10/23/01	414	15.8	7.35	829	13.5	0.28	0.32
M3-7	163017	10/23/01	390	12.2	7.34	780	14.4	0.23	0.23
M3-8	163018	10/23/01	390	12.2	7.43	779	15.1	0.11	0.12
M3-9	163019	10/23/01	365	16.5	6.83	733	5.19	0.31	0.35
M3-10	1630110	10/23/01	335	14.2	7.12	671	8.94	0.37	0.39
M3-11	1630111	10/23/01	335	15.4	7.34	672	5.34	0.39	0.46
M3-12	1630112	10/23/01	344	13	7.37	690	9.1	0.27	0.3
M3-13	1630113	10/23/01	341	12.7	7.21	684	8.80	0.3	0.34
M3-14	1630114	10/23/01	346	12	7.36	693	9.23	0.15	0.15
M3-SW	1630115	10/23/01	NM	NM	NM	NM	3.77	0.14	0.21
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M3-1	173011	11/20/01	388	12.5	7.38	778	8.59	0.33	0.33
M3-2	173012	11/20/01	405	12.3	4.35	809	12.8	0.35	0.35
M3-3	173013	11/20/01	441	12.7	7.32	881	13.5	0.38	0.38
M3-4	173014	11/20/01	339	12.4	7.44	679	5.07	0.06	0.06
M3-5	173015	11/20/01	73	12.4	7.59	145	0.61	<0.05	0.05
M3-6	173016	11/20/01	406	12.2	7.37	813	13.5	0.28	0.28
M3-7	173017	11/20/01	391	12.2	7.41	782	14.3	0.24	0.24
M3-8	173018	11/20/01	392	12.1	7.44	785	15.4	0.12	0.12
M3-9	173019	11/20/01	379	14.5	7.21	758	5.27	0.37	0.39
M3-10	1730110	11/20/01	334	13.2	7.24	669	8.26	0.4	0.4
M3-11	1730111	11/20/01	340	13.2	7.45	680	5.15	0.43	0.44
M3-12	1730112	11/20/01	344	11.8	7.42	687	9.05	0.29	0.29
M3-13	1730113	11/20/01	342	12.4	7.29	684	8.68	0.33	0.33
M3-14	1730114	11/20/01	347	11.9	7.45	693	8.88	0.16	0.16
M3-SW	1730115	11/20/01	NM	NM	NM	NM	3.65	0.16	0.20
ISDAWellID	SampleNo	SampleDate	TDS (mg/L)	Temp C	pH	SpecCond (uS)	Nitrate (mg/L)	OrthoP (mg/L)	TotalP (mg/L)
M3-1	183011	12/27/01	NM	NM	NM	NM	9.11	0.31	0.31
M3-2	183012	12/27/01	NM	NM	NM	NM	13.2	0.33	0.33
M3-3	183013	12/27/01	NM	NM	NM	NM	13.6	0.38	0.38
M3-4	183014	12/27/01	NM	NM	NM	NM	5.37	0.07	0.07
M3-5	183015	12/27/01	NM	NM	NM	NM	0.60	<0.05	<0.05
M3-6	183016	12/27/01	NM	NM	NM	NM	12.6	0.3	0.3
M3-7	183017	12/27/01	NM	NM	NM	NM	15.2	0.26	0.26
M3-8	183018	12/26/01	NM	NM	NM	NM	16.4	0.12	0.36
M3-9	183019	12/27/01	NM	NM	NM	NM	4.31	0.3	0.32
M3-10	1830110	12/27/01	NM	NM	NM	NM	8.46	0.41	0.41
M3-11	1830111	12/29/01	NM	NM	NM	NM	5.60	0.47	0.47
M3-12	1830112	12/27/01	NM	NM	NM	NM	9.14	0.29	0.29
M3-13	1830113	12/27/01	NM	NM	NM	NM	8.51	0.3	0.31
M3-14	1830114	12/27/01	NM	NM	NM	NM	9.12	0.16	0.16
M3-SW	1830115	12/27/01	NM	NM	NM	NM	3.91	0.16	0.36

Appendix B. Discharge Measurements

Site M-1

Date	Site	Discharge (CFS)
1-11-01	M1 Upstream	56.4
	M1 Downstream	60.6
	Gain (+)	4.2
2-7-01	M1 Upstream	53.7
	M1 Downstream	60.7
	Gain (+)	7
4-16-01	M1 Upstream	54.3
	M1 Downstream	56.6
	Gain (+)	2.3
5-4-01	M1 Upstream	80.63
	M1 Downstream	87.45
	Gain (+)	6.82
6-25-01	M1 Upstream	97.6
	M1 Downstream	87.4
	Loss (-)	10.2
7-13-01	M1 Upstream	108.2
	M1 Downstream	110.2
	Loss (-)	2
8-16-01	M1 Upstream	82.31
	M1 Downstream	81.3
	Loss (-)	1
10-12-01	M1 Upstream	56.7
	M1 Downstream	58.67
	Gain (+)	1.97
11-6-01	M1 Upstream	37.98
	M1 Downstream	43.85
	Gain (+)	5.87

Site M-3

Date	Site	Discharge (CFS)
1/1/01	M3 Upstream	50.8
	M3 Downstream	51.6
	Gain (+)	0.8
2/7/01	M3 Upstream	46
	M3 Downstream	46.88
	Gain (+)	0.88
4/16/01	M3 Upstream	52.8
	M3 Downstream	56.2
	Gain (+)	3.4
5/4/01	M3 Upstream	30.19
	M3 Downstream	30.86
	Gain (+)	0.67
6/25/01	M3 Upstream	15.9
	M3 Downstream	13.4
	Loss (-)	2.5
7/13/01	M3 Upstream	46.5
	M3 Downstream	43
	Loss (-)	3.5
8/16/01	M3 Upstream	15.95
	M3 Downstream	11.07
	Loss (-)	4.88
10/11/01	M3 Upstream	53.85
	M3 Downstream	50.31
	Loss (-)	3.54
11/6/01	M3 Upstream	41.52
	M3 Downstream	40.5
	Loss (-)	1.02

Appendix C Soil Sample Analytical Results

Site M-1

ISDA Soil Sample ID	Sample Number	Sample Date	Sample Depth (Feet)	Water pH	Soluble Salts (ECe)	Nitrates (ppm)	Phosphorous (ppm)	Potassium (ppm)
M1S1	M1S101	5/29/01	0.5	8.2	0.2	21	20	356
M1S2	M1S201	5/29/01	0.5	8.6	0.3	23	17	356
M1S3	M1S301	5/29/01	0.5	8.7	0.46	5	5	305
M1S1	M1S102	5/29/01	1	8.5	0.36	35	19	352
M1S2	M1S202	5/29/01	1	8.7	0.34	31	35	336
M1S3	M1S302	5/29/01	1	8.6	0.32	3	3	248
M1S1	M1S103	5/29/01	2	8.6	0.23	29	11	290
M1S2	M1S203	5/29/01	2	8.5	0.32	13	21	250
M1S3	M1S303	5/29/01	2	8.7	0.24	4	3	190
M1S1	M1S104	5/29/01	3	8.6	0.2	10	11	220
M1S2	M1S204	5/29/01	3	8.4	0.2	6	10	227
M1S3	M1S304	5/29/01	3	8.4	0.2	4	4	163
M1S1	M1S105	5/29/01	4	8.4	0.25	5	9	254
M1S2	M1S205	5/29/01	4	8.5	0.21	9	16	396
M1S3	M1S305	5/29/01	4	8.4	0.24	6	5	170

Soil Sample Analytical Results continued.

Site M-3

ISDA Soil Sample ID	Sample Number	Sample Date	Sample Depth (Feet)	Water pH	Soluble Salts (ECe)	Nitrates (ppm)	Phosphorous (ppm)	Potassium (ppm)
M3S1	M3S101	5/23/01	0.5	8.2	0.36	28	18	127
M3S2	M3S201	5/23/01	0.5	8	0.4	30	19	186
M3S3	M3S301	5/23/01	0.5	7.5	0.35	7	14	304
M3S4	M3S401	5/23/01	0.5	8.1	0.42	17	17	244
M3S5	M3S501	5/23/01	0.5	8.1	0.5	2	15	298
M3S6	M3S601	5/23/01	0.5	8.6	0.53	5	5	203
M3S8	M3S801	5/23/01	0.5	8.1	0.65	25	16	262
M3S9	M3S901	5/23/01	0.5	8.5	0.33	5	12	327
M3S10	M3S1001	5/23/01	0.5	8.2	0.48	9	14	392
M3S1	M3S102	5/23/01	1	8.5	0.49	34	17	235
M3S2	M3S202	5/23/01	1	7.9	0.41	27	18	193
M3S3	M3S302	5/23/01	1	7.7	0.37	7	15	339
M3S4	M3S402	5/23/01	1	8.2	0.48	22	15	230
M3S5	M3S502	5/23/01	1	8.1	0.46	5	12	292
M3S6	M3S602	5/23/01	1	8.7	0.58	7	3	230
M3S7	M3S701	5/23/01	1	8.6	0.49	2	12	287
M3S8	M3S802	5/23/01	1	8	0.66	29	14	280
M3S9	M3S902	5/23/01	1	8.5	0.34	6	10	352
M3S10	M3S1002	5/23/01	1	8.2	0.52	18	16	434
M3S2	M3S203	5/23/01	1.5	7.9	0.48	33	21	234
M3S1	M3S103	5/23/01	2	8.7	0.48	32	15	278
M3S2	M3S204	5/23/01	2	8.2	0.46	32	17	273
M3S3	M3S303	5/23/01	2	8.2	0.53	6	4	223
M3S4	M3S403	5/23/01	2	8.3	0.41	19	5	181
M3S5	M3S503	5/23/01	2	8.6	0.3	4	14	234
M3S6	M3S603	5/23/01	2	8.7	0.4	2	3	196
M3S7	M3S702	5/23/01	2	8.8	1.04	2	14	447
M3S8	M3S803	5/23/01	2	8.5	0.36	19	3	213
M3S9	M3S903	5/23/01	2	8.8	0.28	3	13	306
M3S10	M3S1003	5/23/01	2	8.3	0.45	12	9	404
M3S2	M3S205	5/23/01	3	8.2	0.24	16	6	297
M3S3	M3S304	5/23/01	3	8.3	0.28	7	3	205
M3S4	M3S404	5/23/01	3	8.5	0.36	18	3	198
M3S5	M3S504	5/23/01	3	8.6	0.28	2	16	247
M3S7	M3S703	5/23/01	3	8.8	0.44	3	4	426
M3S8	M3S804	5/23/01	3	8.7	0.37	7	3	221
M3S9	M3S904	5/23/01	3	8.7	0.26	3	3	337
M3S10	M3S1004	5/23/01	3	8.7	0.28	7	30	127
M3S2	M3S206	5/23/01	4	8.3	0.23	14	7	208
M3S3	M3S305	5/23/01	4	8.3	0.28	3	4	215
M3S4	M3S405	5/23/01	4	8.6	0.2	8	3	210
M3S5	M3S505	5/23/01	4	8.7	0.27	2	10	269
M3S7	M3S704	5/23/01	4	8.7	0.4	4	6	434
M3S8	M3S805	5/23/01	4	8.5	0.44	6	3	308
M3S9	M3S905	5/23/01	4	8.7	0.3	3	4	390
M3S10	M3S1005	5/23/01	4	8.6	0.42	4	28	139
M3S2	M3S207	5/23/01	5	8.2	0.28	18	7	223
M3S5	M3S506	5/23/01	5	8.5	0.3	4	9	263

Appendix D. Nitrogen Isotope Analytical Results

Site M-1

Well ID	Sample Date	N-15 ($^{O}/_{OO}$)
M1-1	Dec-00	21.29
M1-2	Dec-00	19.61
M1-3	Dec-00	10.66
M1-4	Dec-00	25.98
M1-5	Dec-00	20.64
M1-6	Dec-00	7.38
M1-7	Dec-00	18.08
M1-9	Dec-00	14.41
M1-10	Dec-00	63.11
M1-11	Dec-00	9.72
M1-12	Dec-00	10.12
M1-SW	Dec-00	9.00

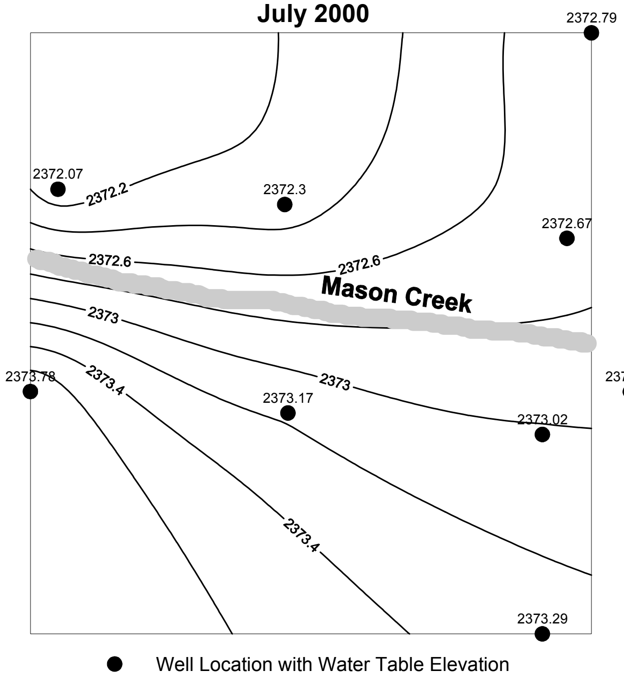
Site M-3

Well ID	Sample Date	N-15 ($^{O}/_{OO}$)
M3-1	Dec-00	5.79
M3-2	Dec-00	35.77
M3-3	Dec-00	4.09
M3-6	Dec-00	5.69
M3-7	Dec-00	5.93
M3-8	Dec-00	4.48
M3-9	Dec-00	15.78
M3-10	Dec-00	11.13
M3-11	Dec-00	11.16
M3-12	Dec-00	4.94
M3-13	Dec-00	5.84
M3-14	Dec-00	5.36
M3-SW	Dec-00	10.71

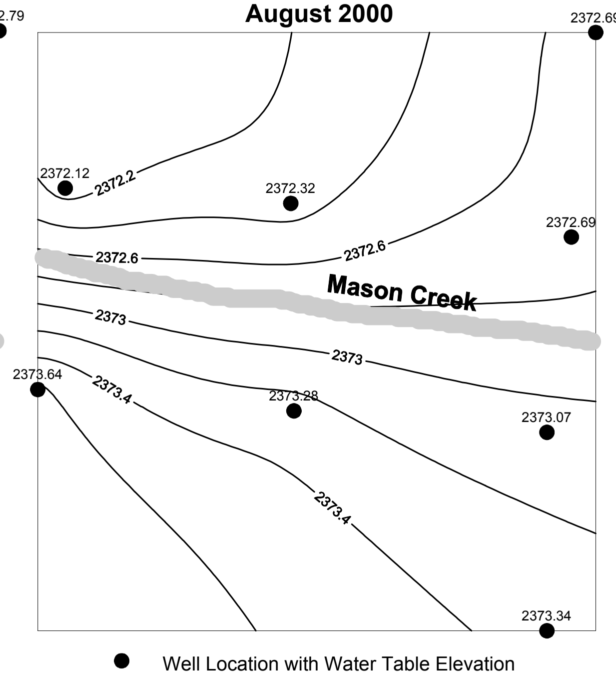
Appendix E. Water Table Contour Maps

Site M-1

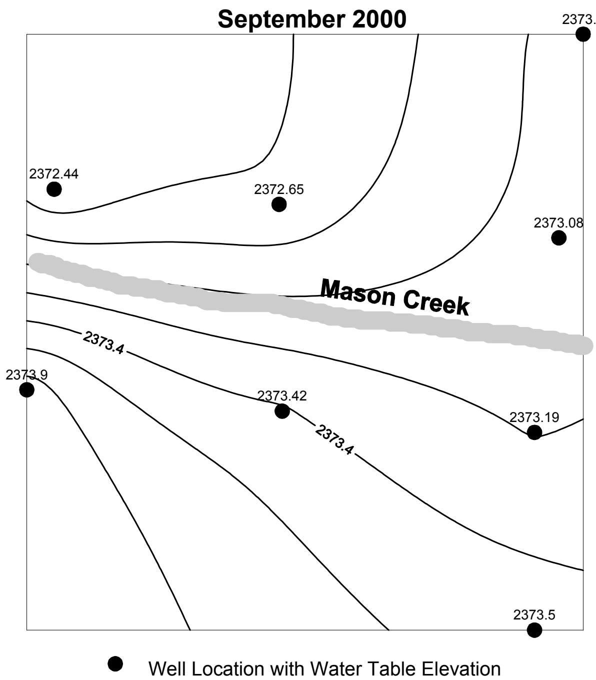
Water Table Contour Map
Mason Creek-Site 1
July 2000



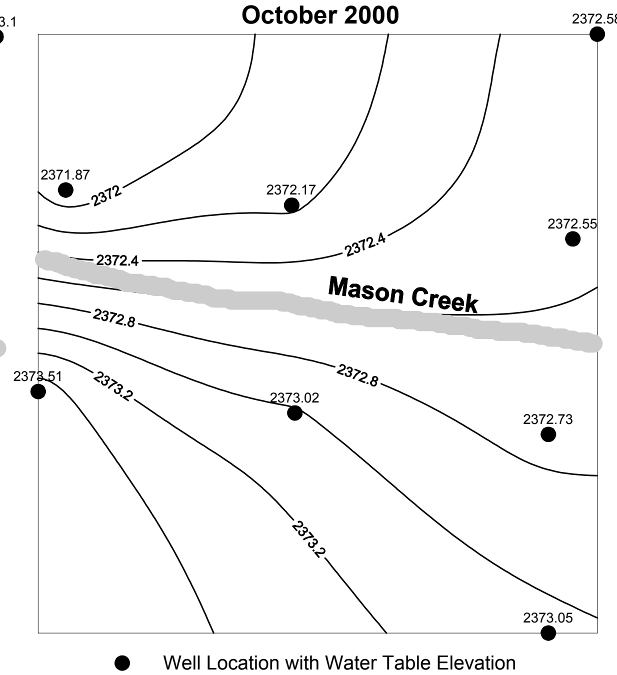
Water Table Contour Map
Mason Creek-Site 1
August 2000



Water Table Contour Map
Mason Creek-Site 1
September 2000

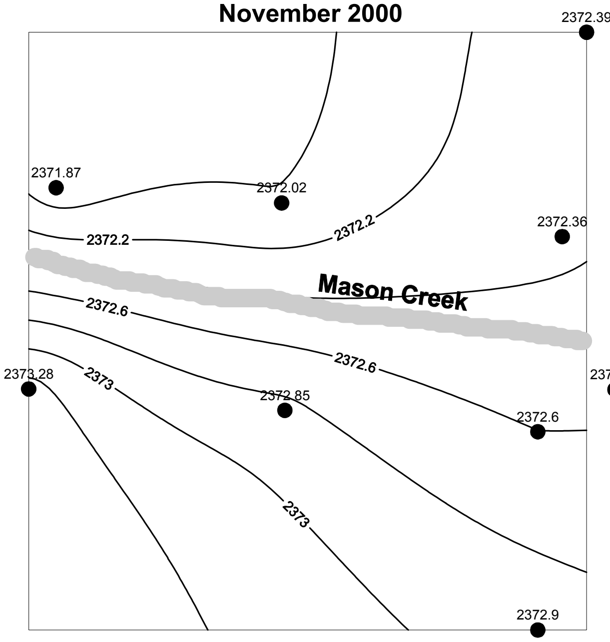


Water Table Contour Map
Mason Creek-Site 1
October 2000



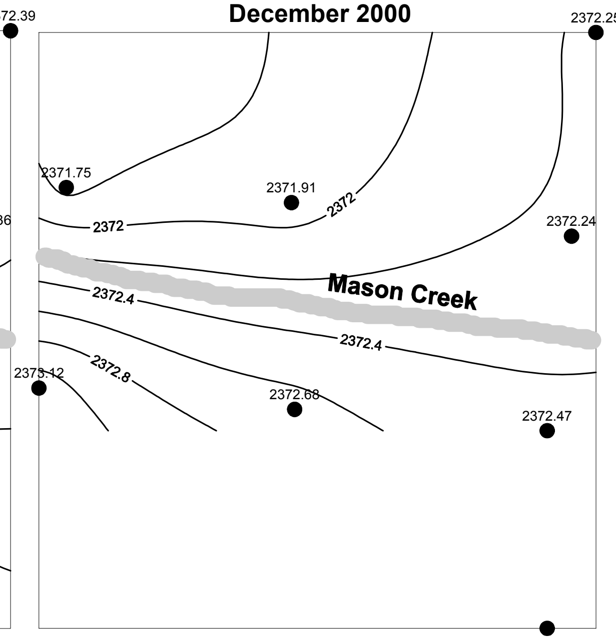
M-1 Water Level Contour Maps continued.

Water Table Contour Map
Mason Creek-Site 1
November 2000



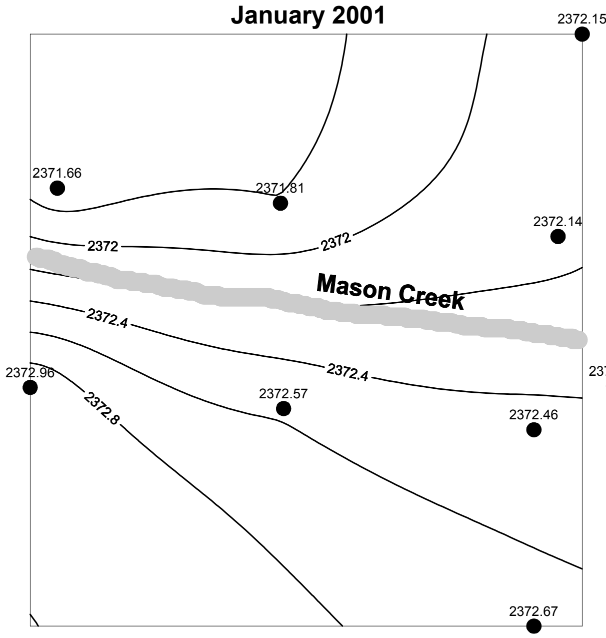
● Well Location with Water Table Elevation

Water Table Contour Map
Mason Creek-Site 1
December 2000



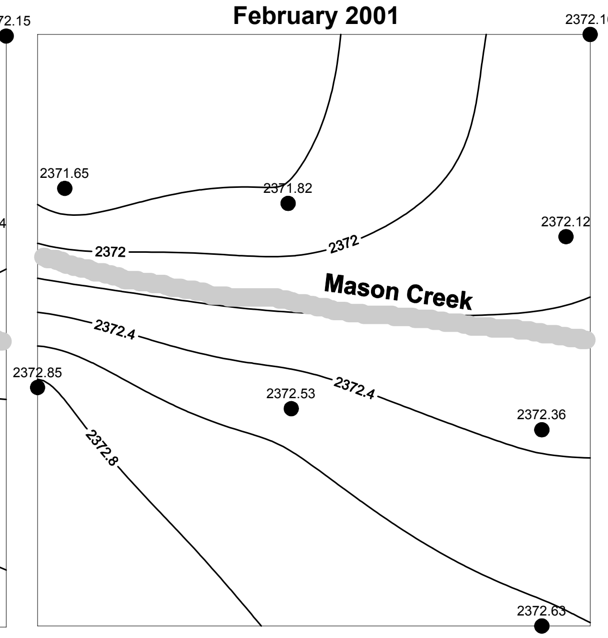
● Well Location with Water Table Elevation

Water Table Contour Map
Mason Creek-Site 1
January 2001



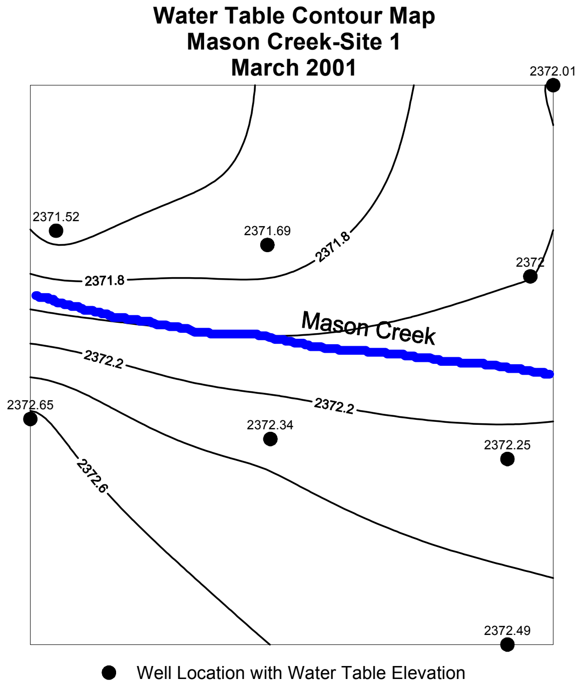
● Well Location with Water Table Elevation

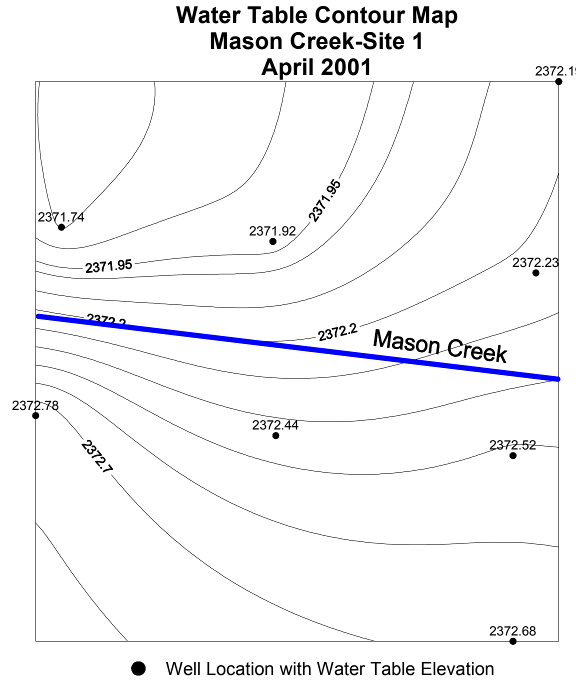
Water Table Contour Map
Mason Creek-Site 1
February 2001

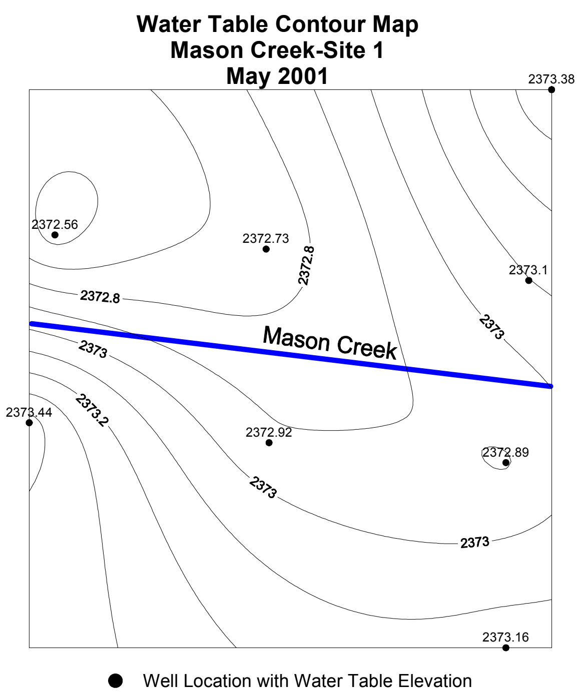


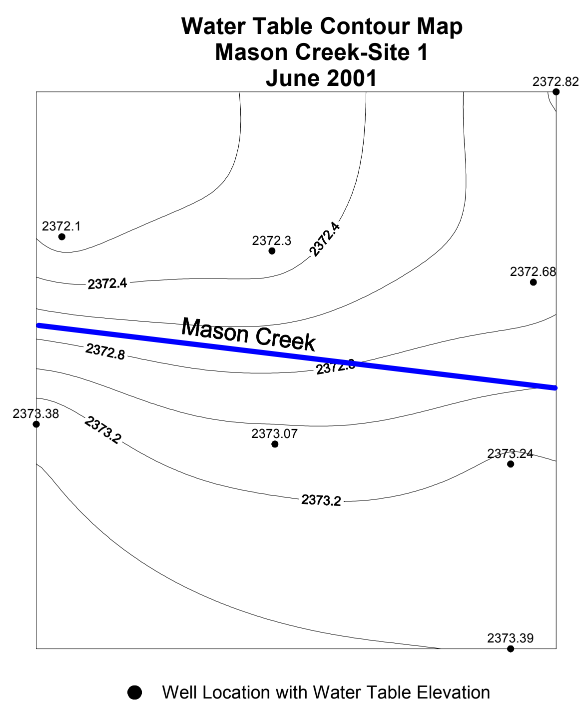
● Well Location with Water Table Elevation

M-1 Water Level Contour Maps continued.



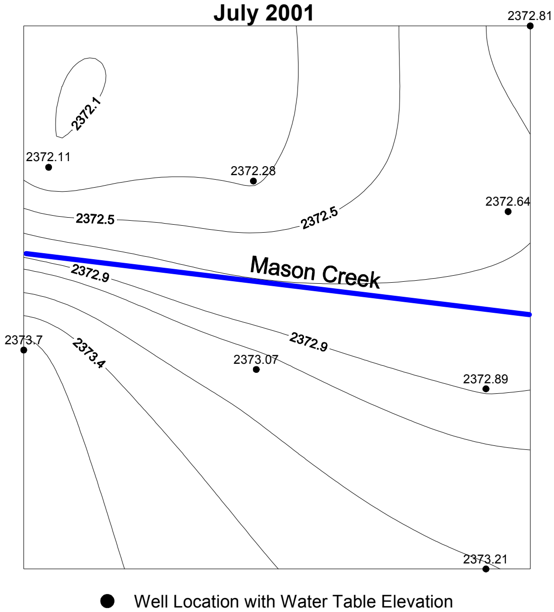




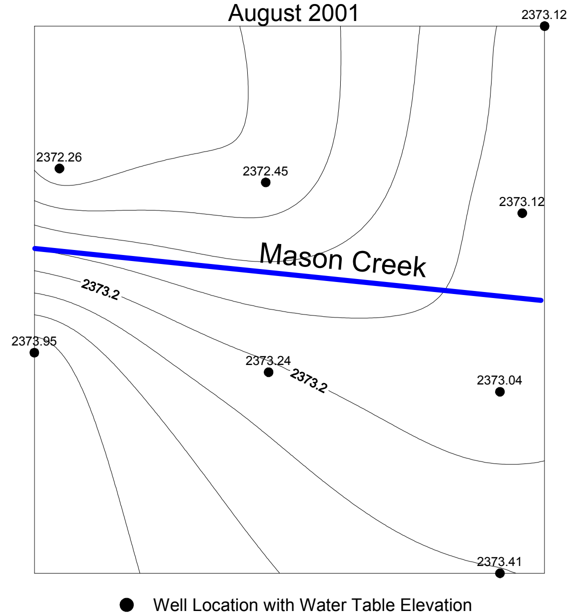


M-1 Water Level Contour Maps continued.

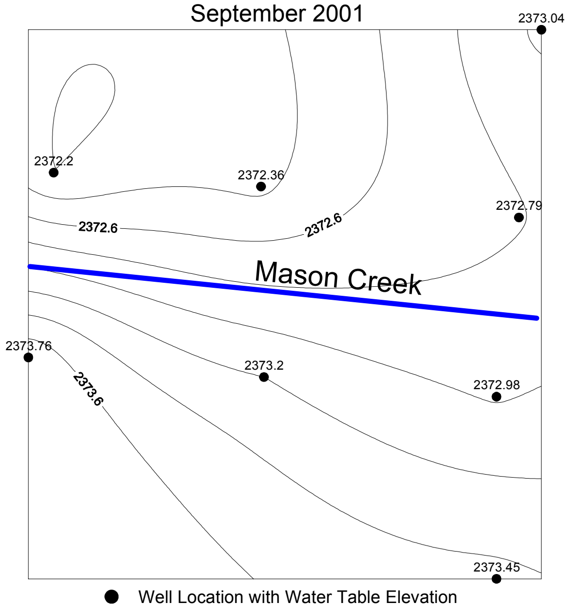
Water Table Contour Map
Mason Creek-Site 1
July 2001



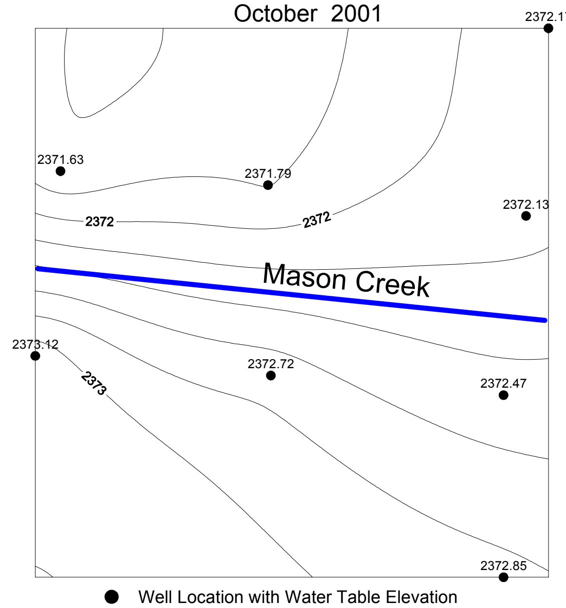
Water Table Contour Map
Mason Creek - Site 1
August 2001



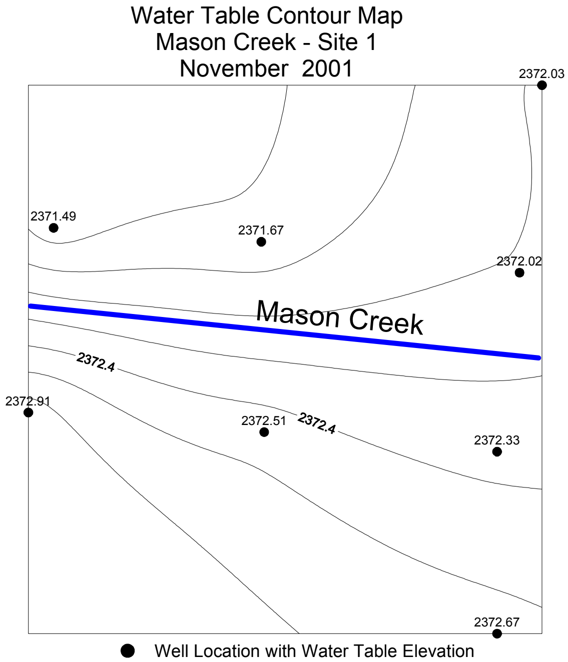
Water Table Contour Map
Mason Creek - Site 1
September 2001

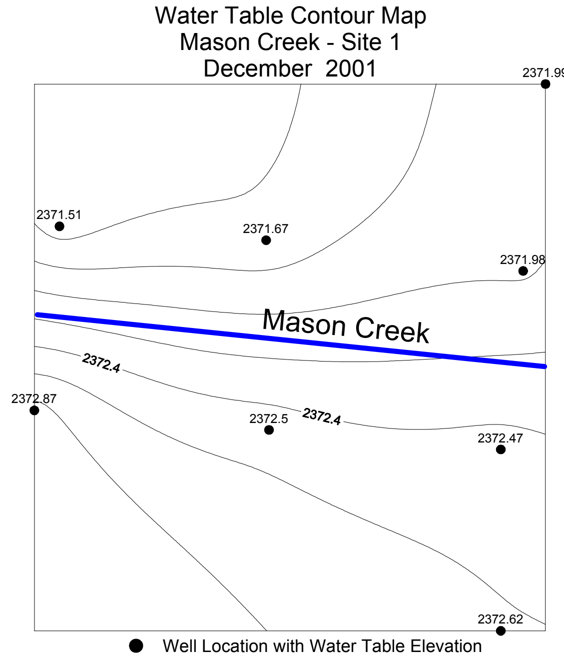


Water Table Contour Map
Mason Creek - Site 1
October 2001



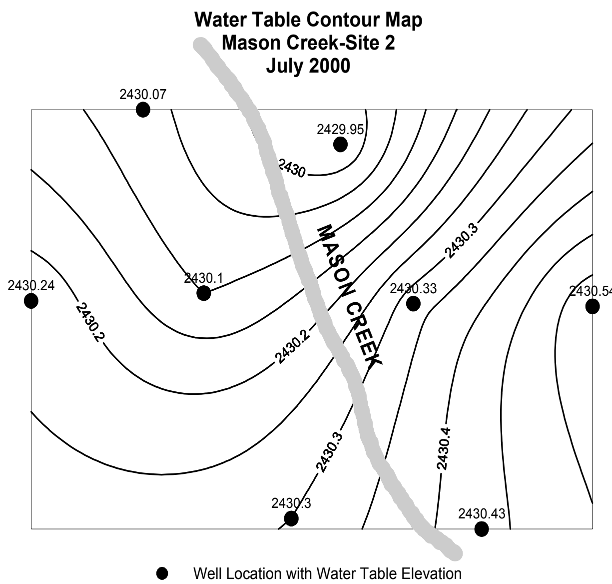
M-1 Water Level Contour Maps continued.

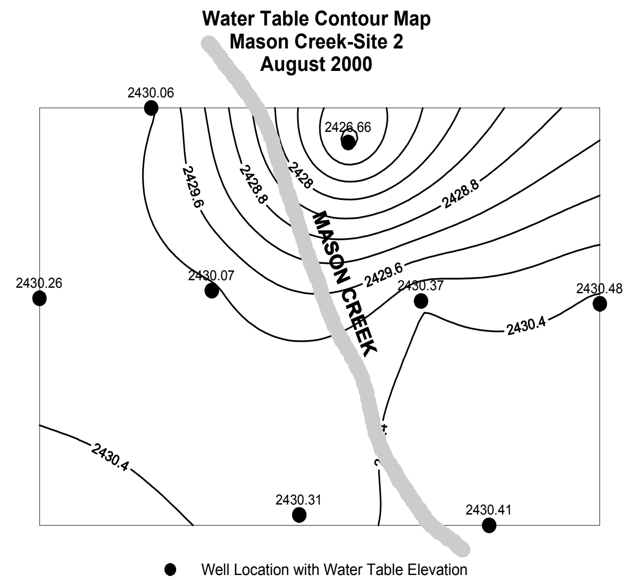


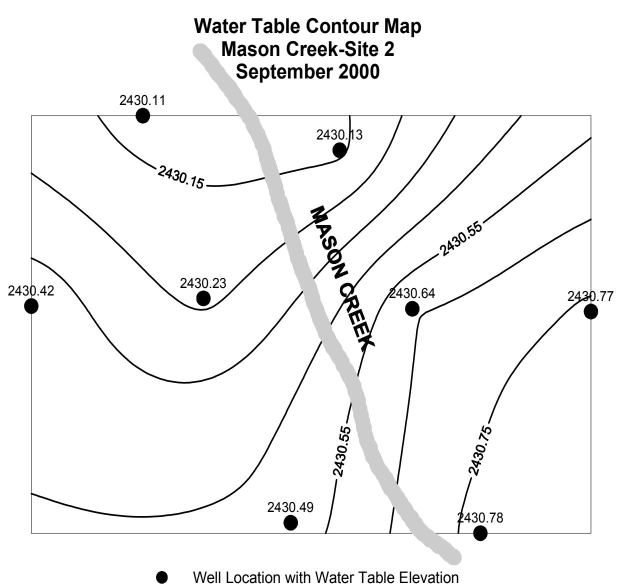


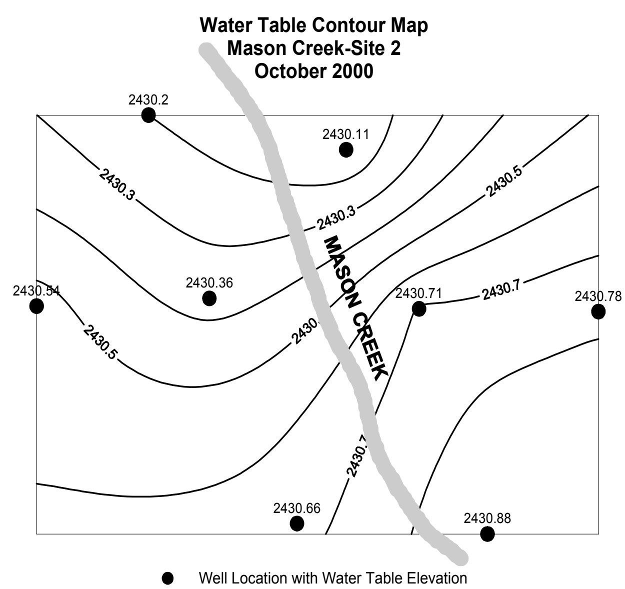
Water Level Contour Maps

Site M-3

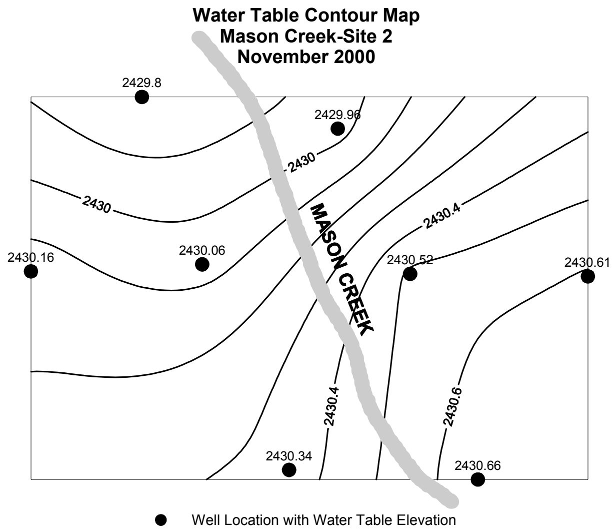


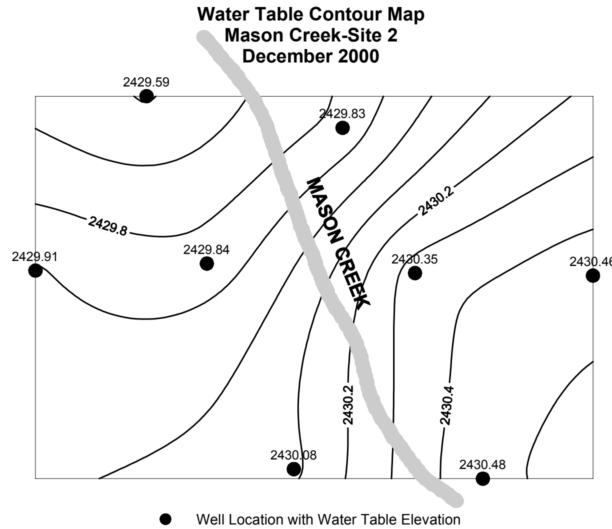


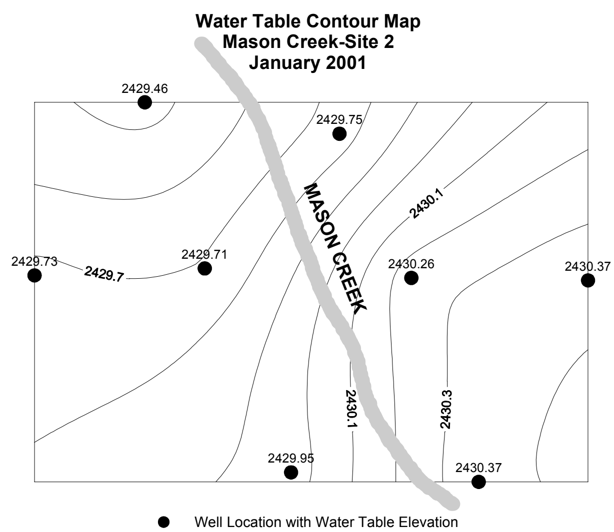


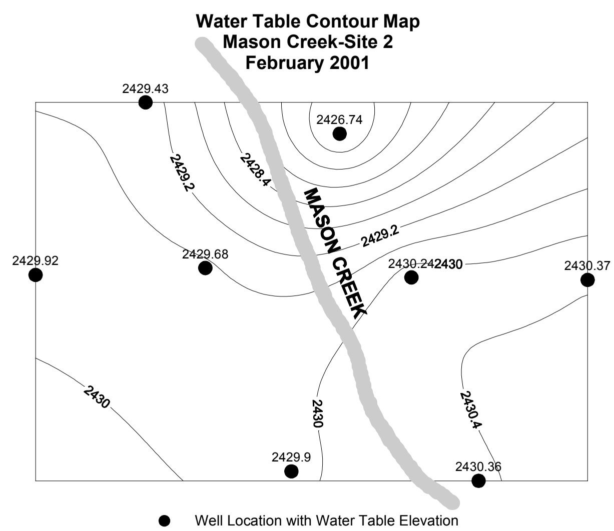


M-3 Water Level Contour Maps continued.

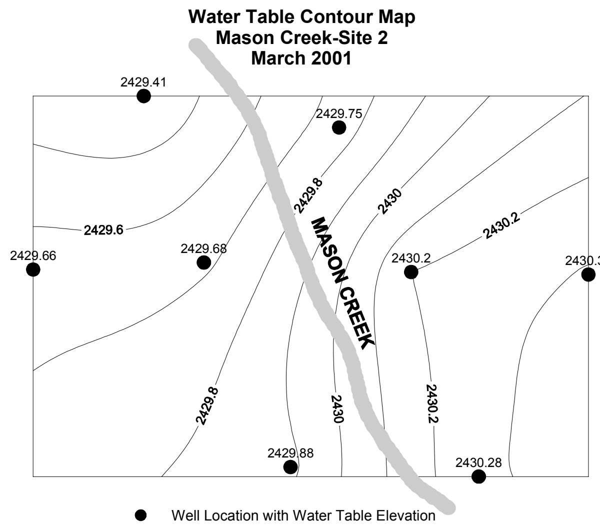


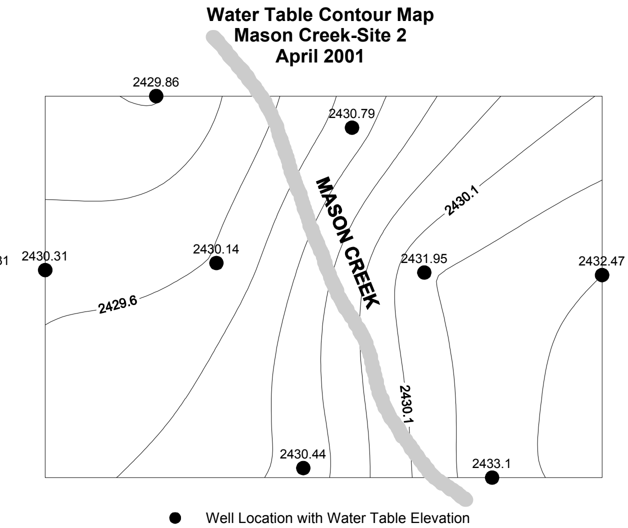


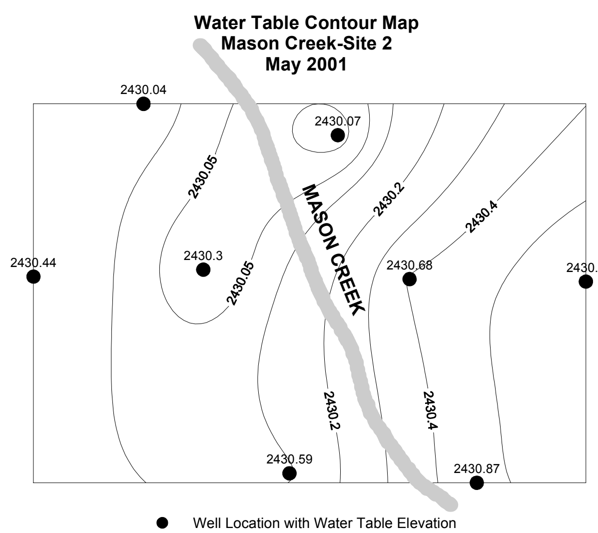


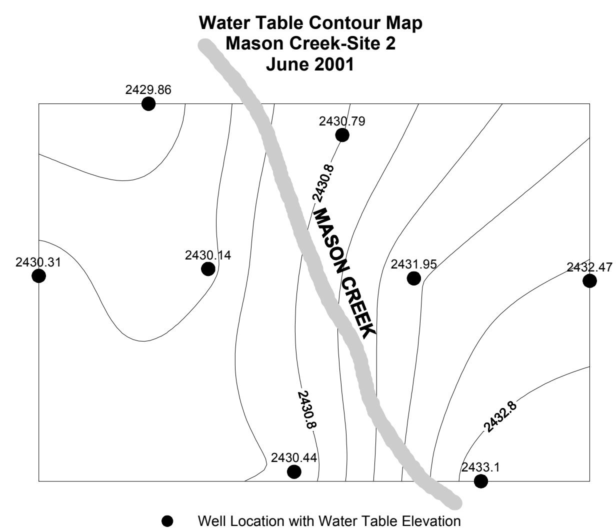


M-3 Water Level Contour Maps continued.



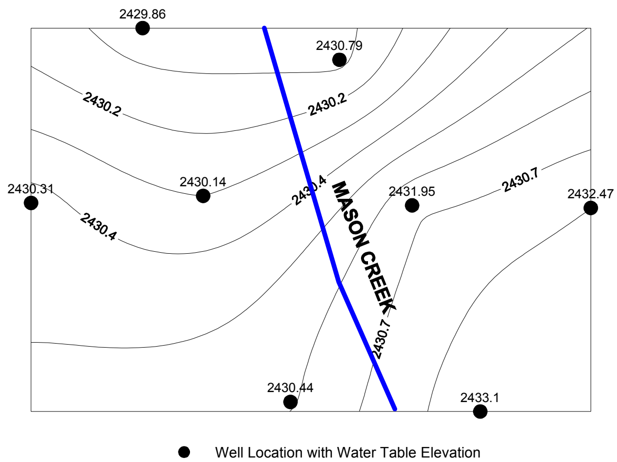




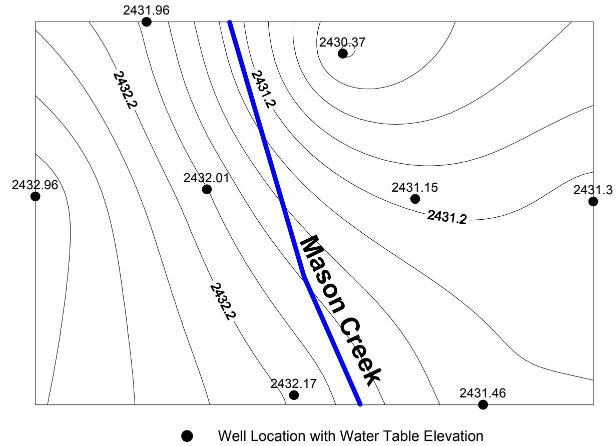


M-3 Water Level Contour Maps continued.

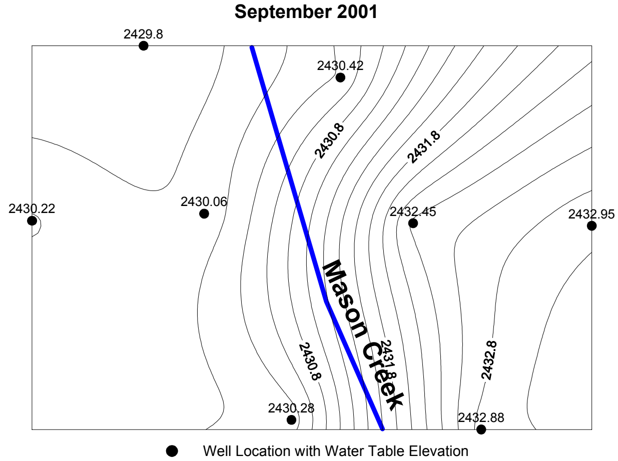
Water Table Contour Map
Mason Creek-Site 2
July 2001



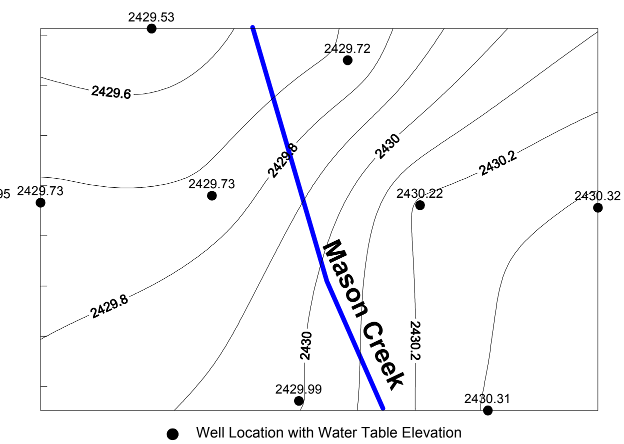
Water Table Contour Map
Mason Creek-Site 2
August 2001



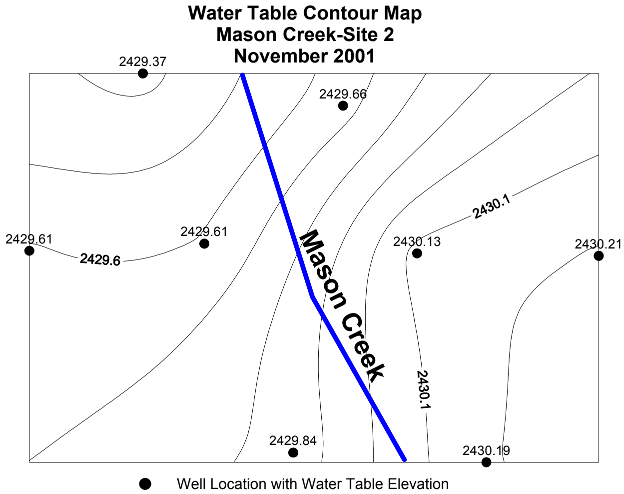
Water Table Contour Map
Mason Creek-Site 2
September 2001

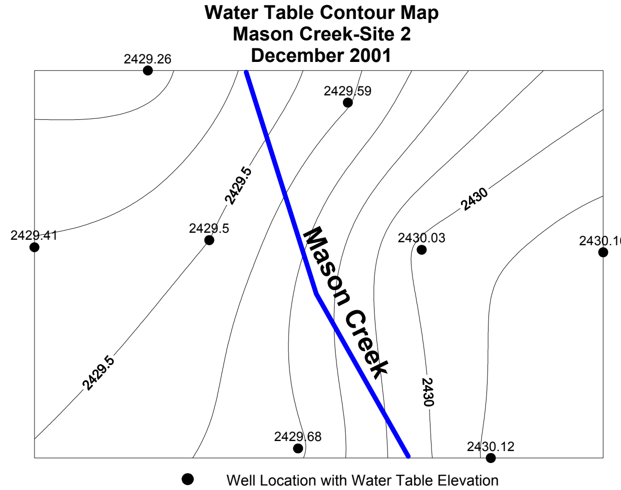


Water Table Contour Map
Mason Creek-Site 2
October 2001



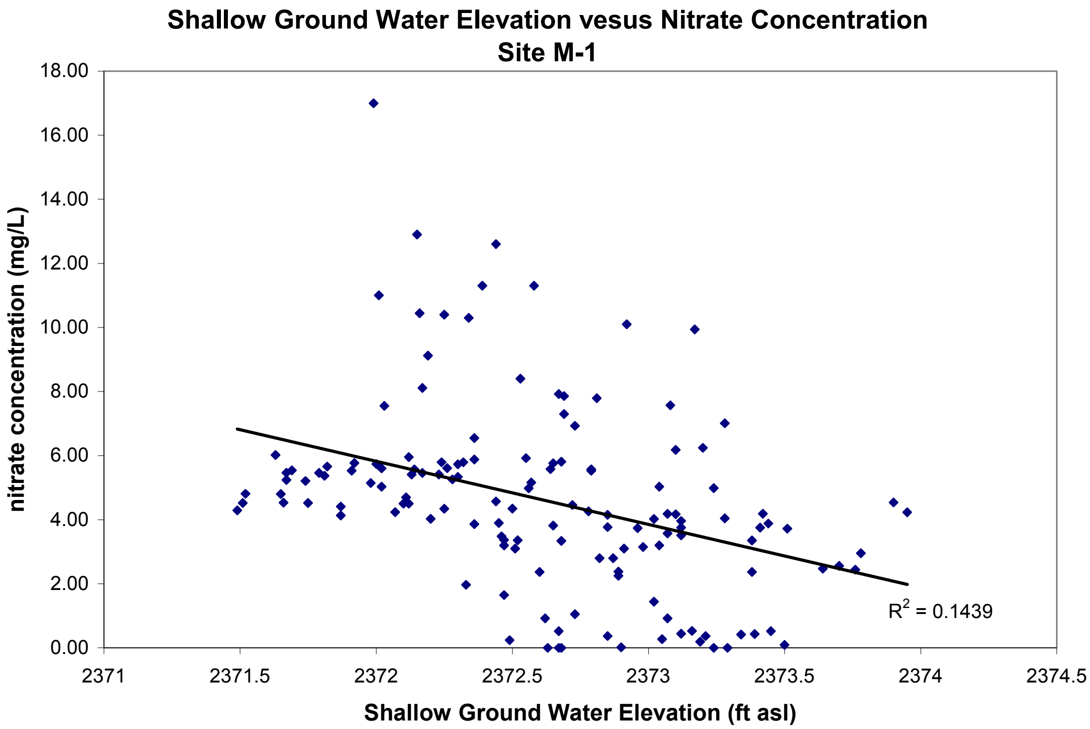
M-3 Water Level Contour Maps continued.

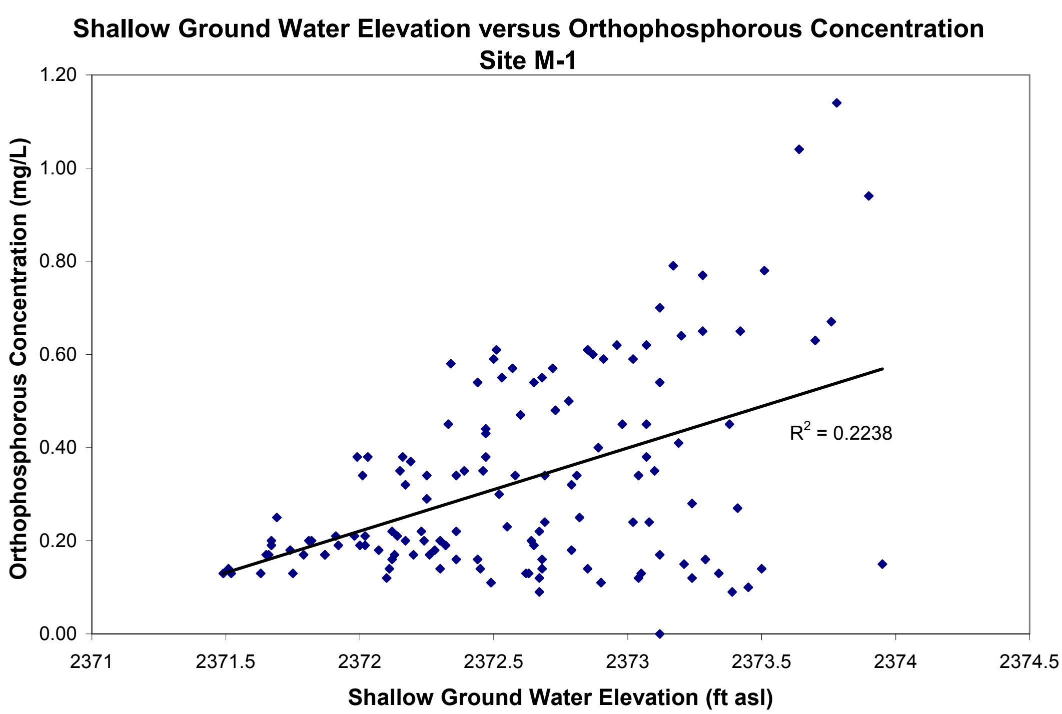




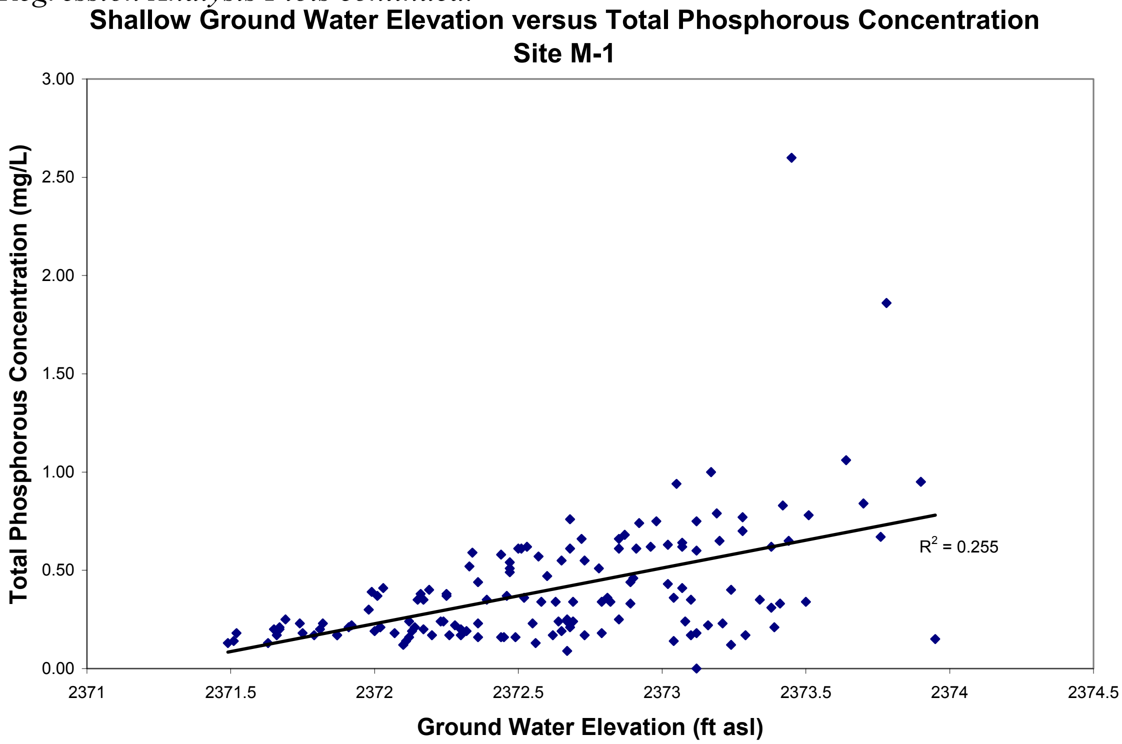
Appendix F. Regression Analysis Plots

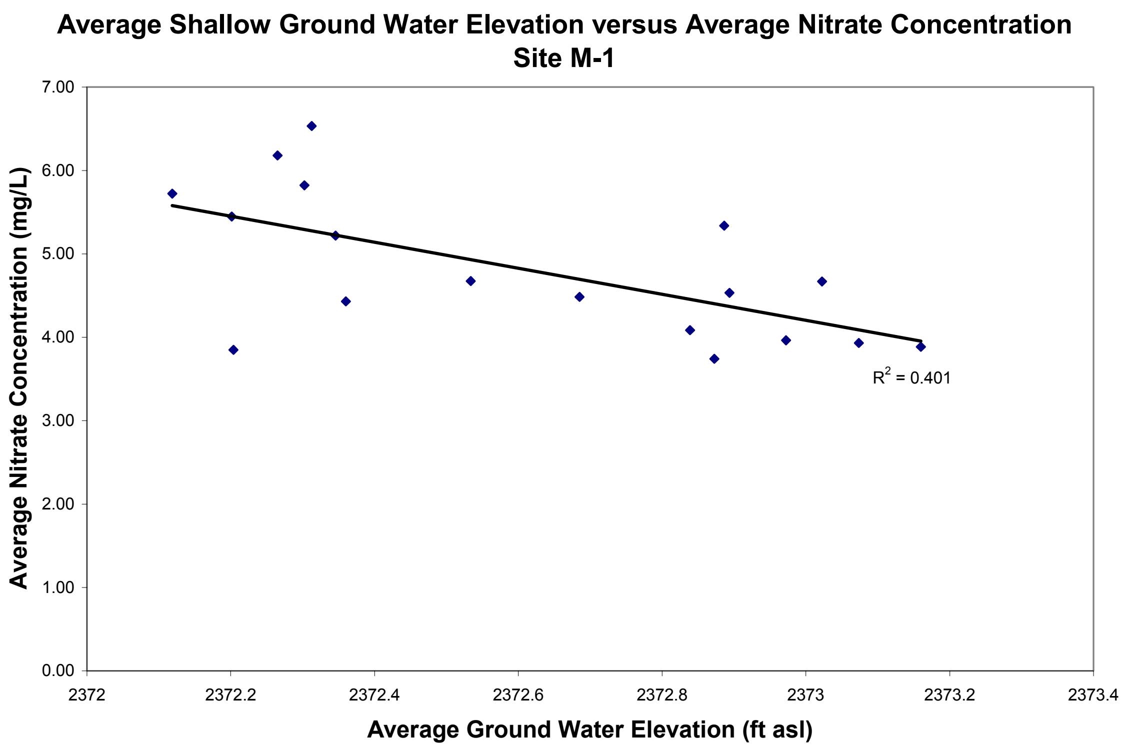
M-1



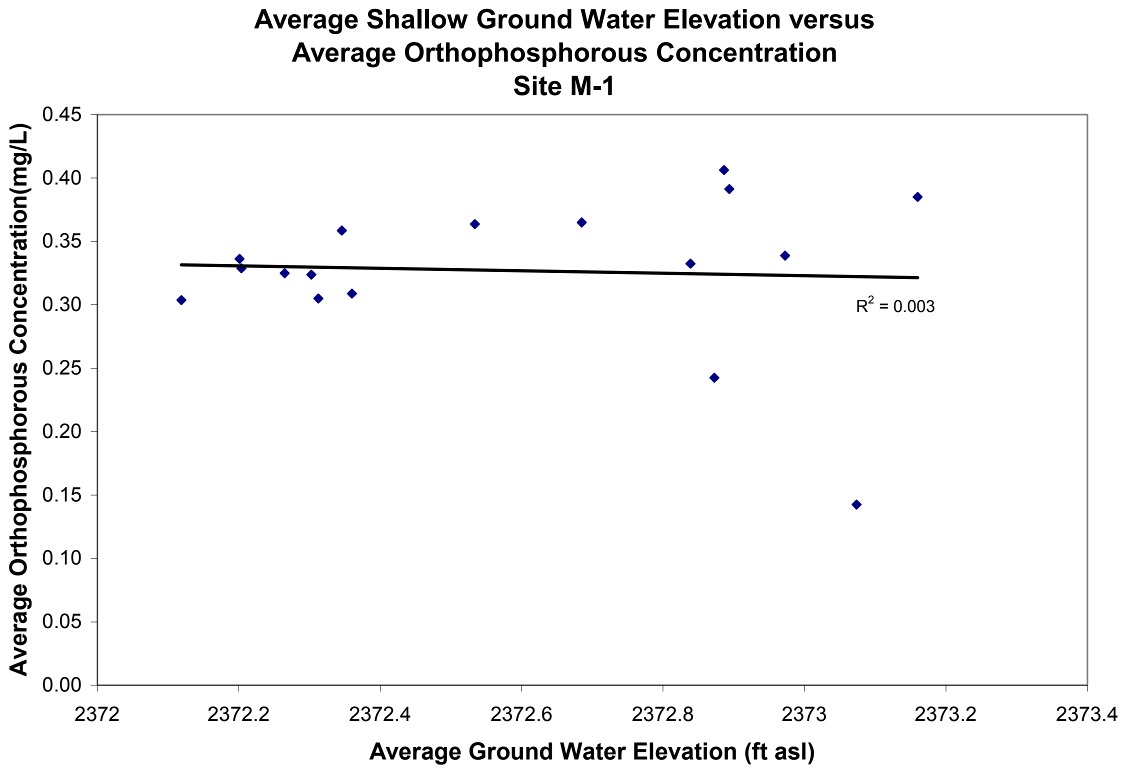


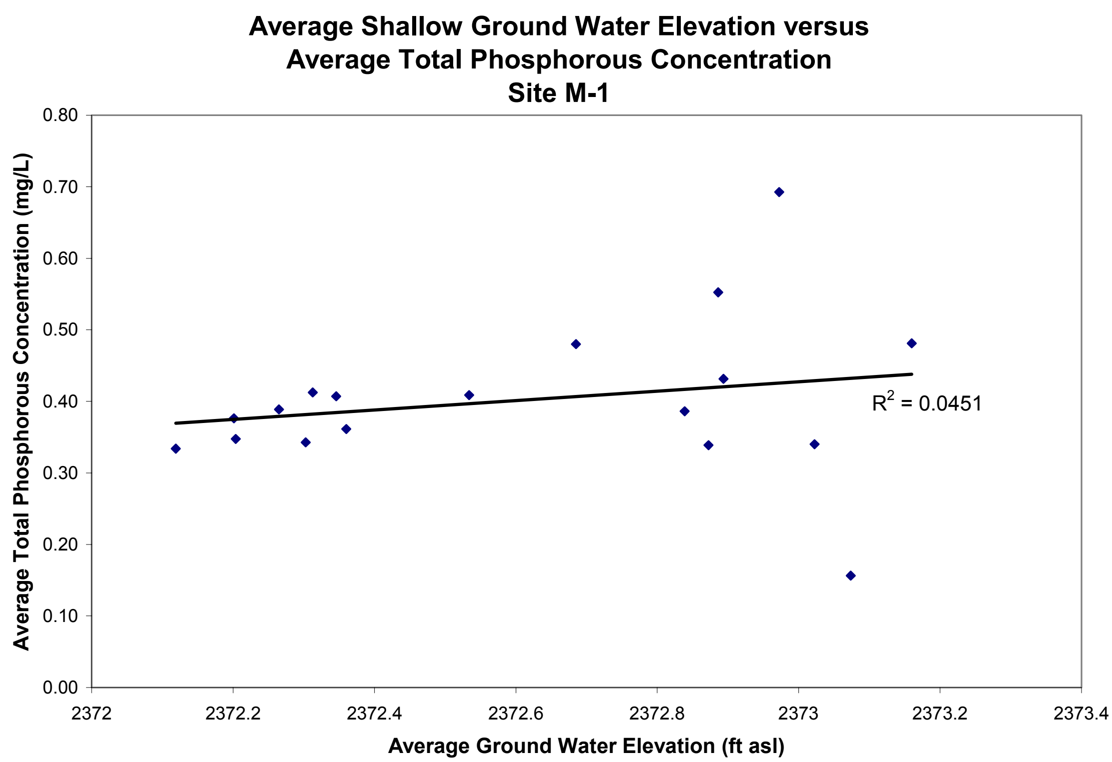
M-1 Regression Analysis Plots continued.



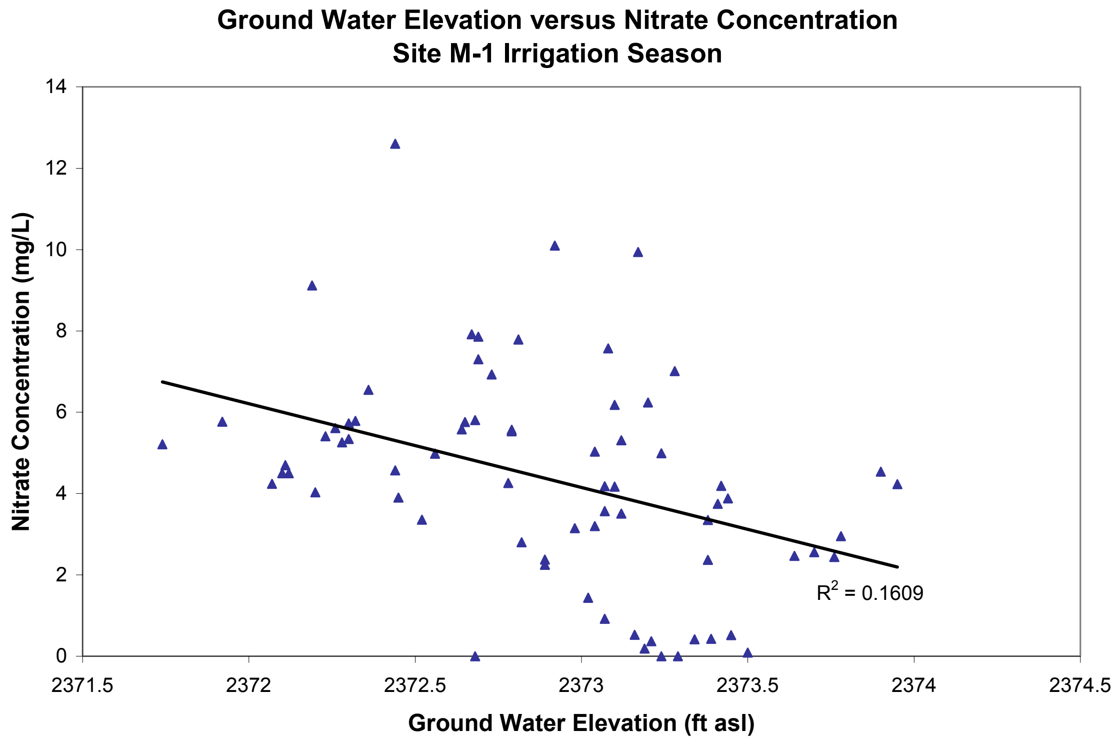


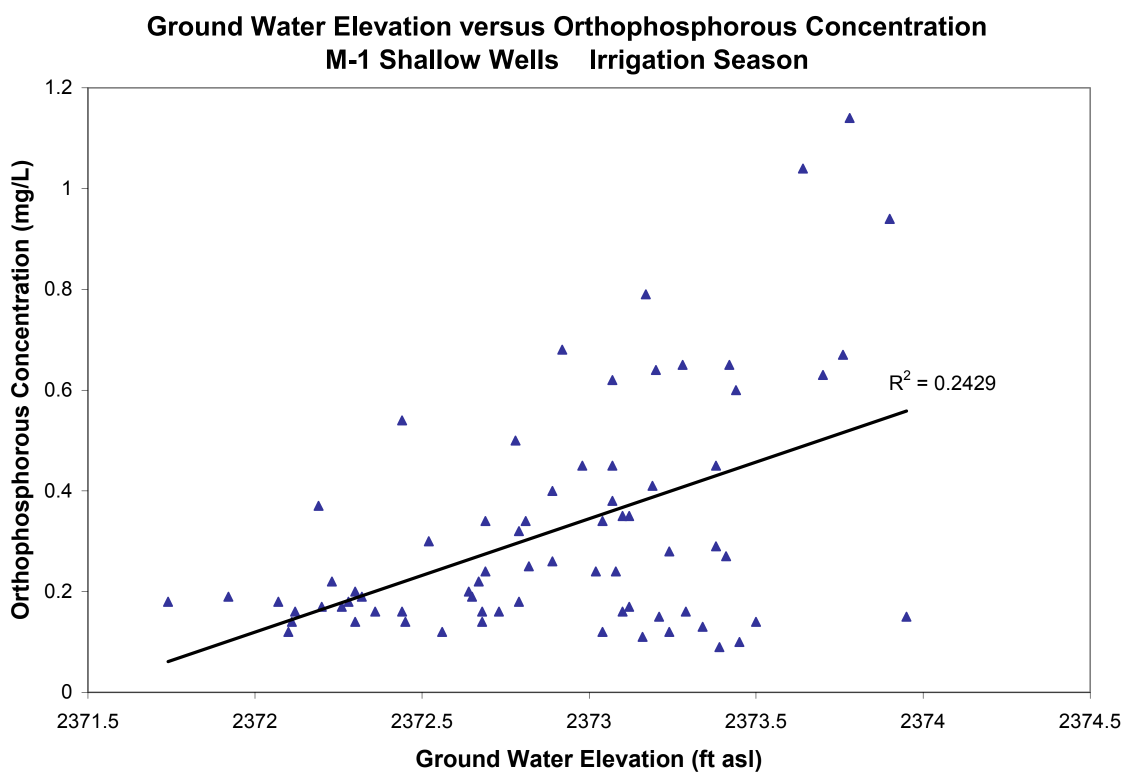
M-1 Regression Analysis Plots continued.





M-1 Regression Analysis Plots continued.





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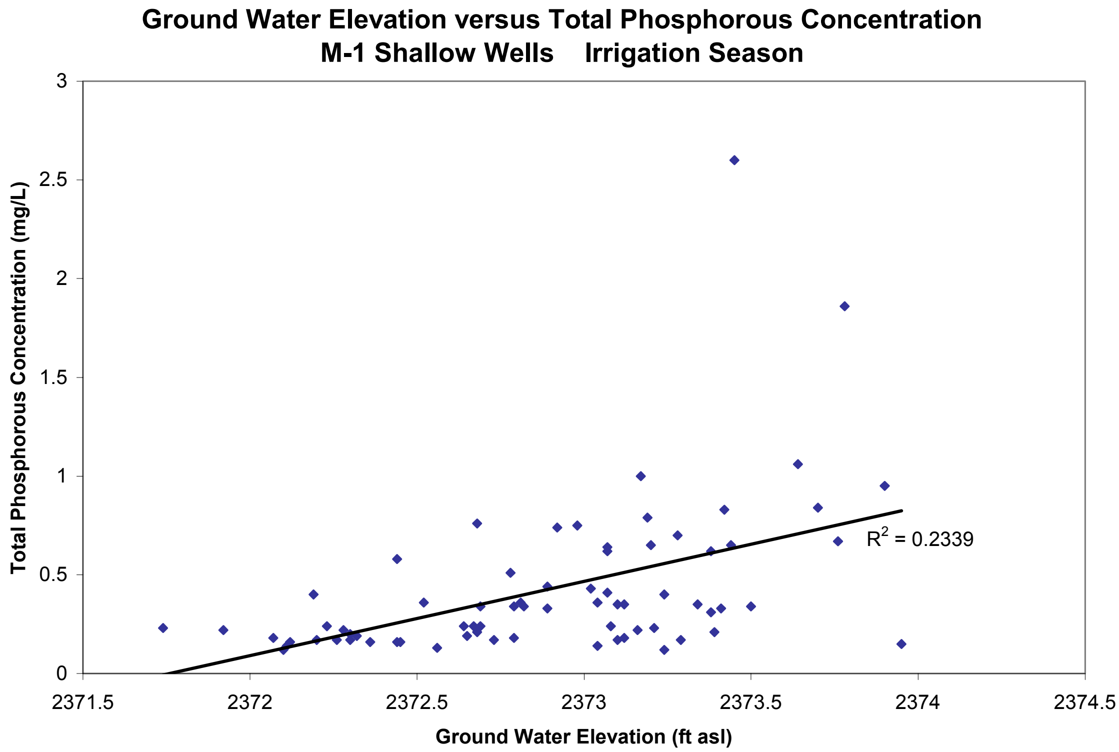

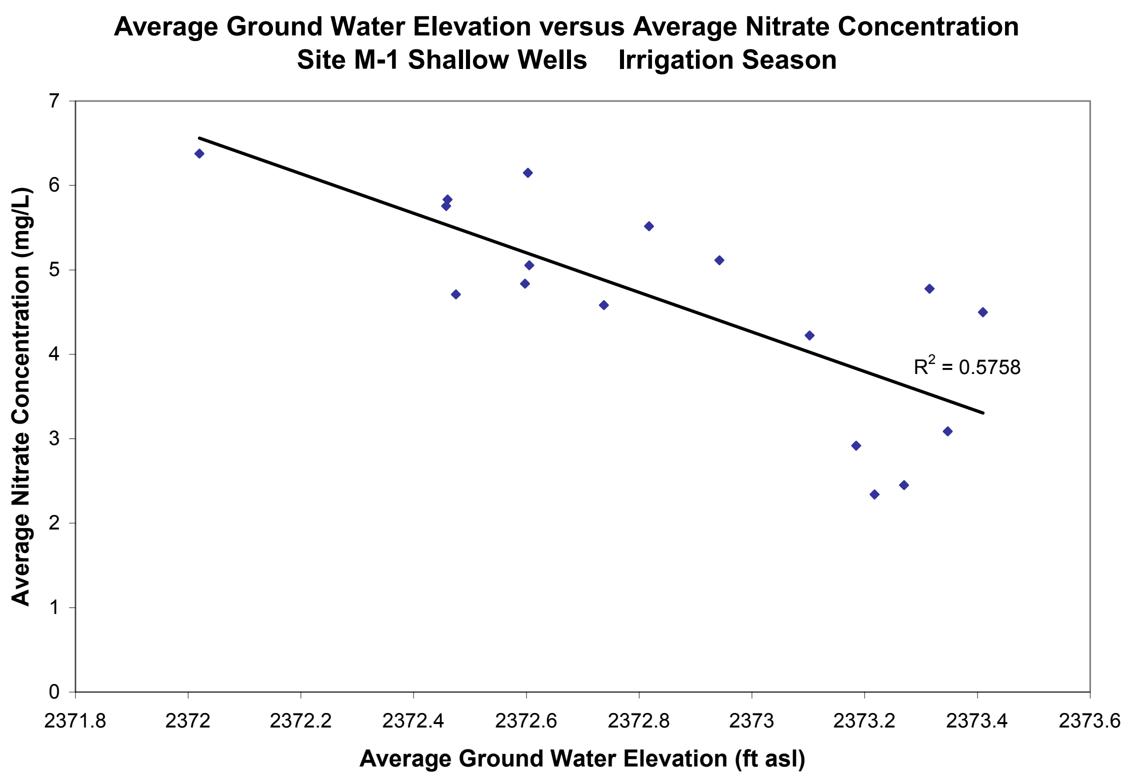

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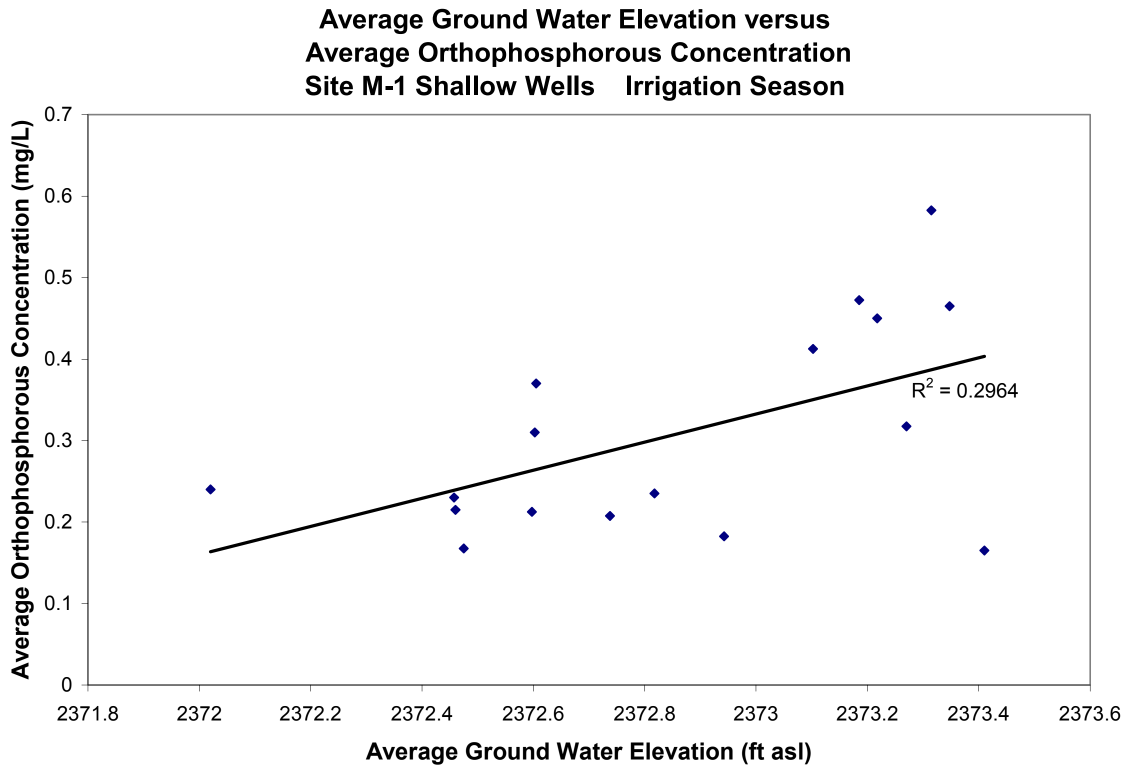

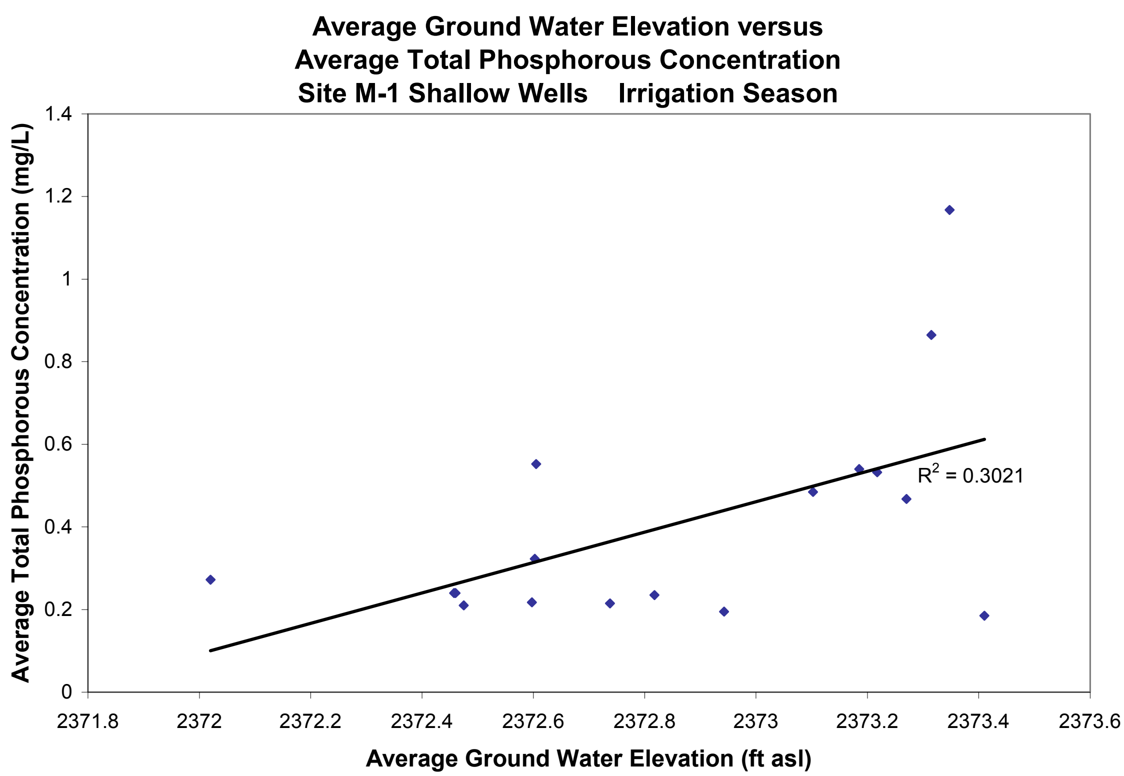

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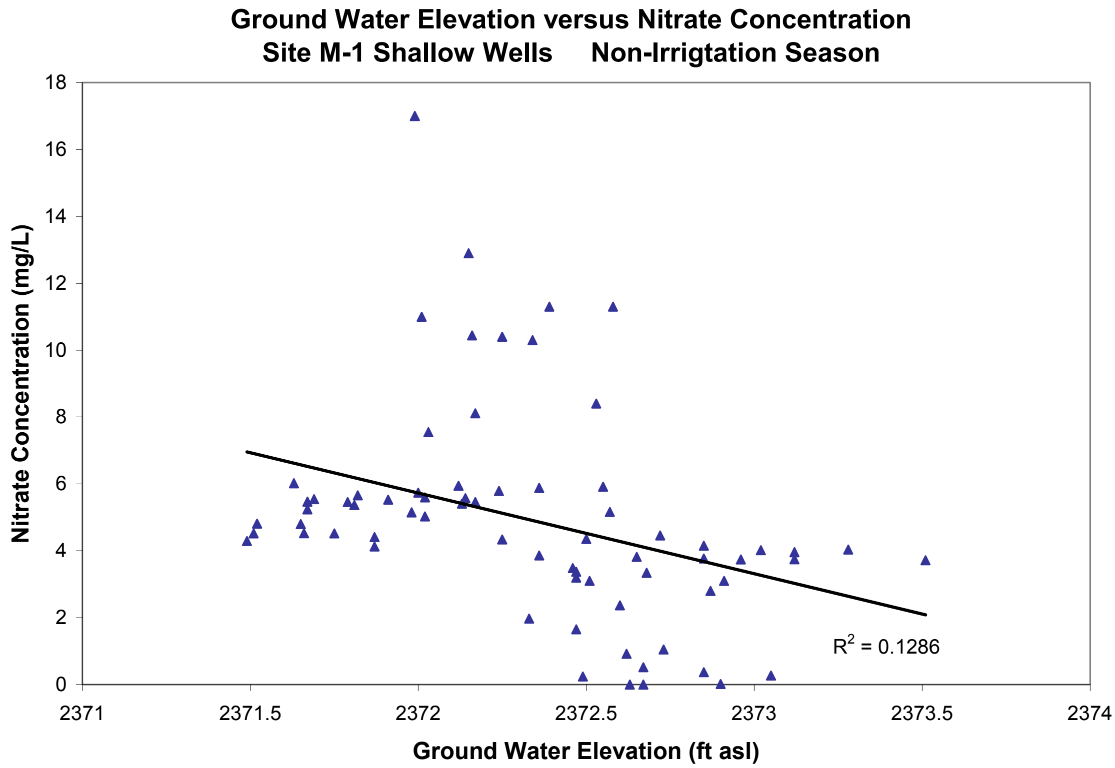

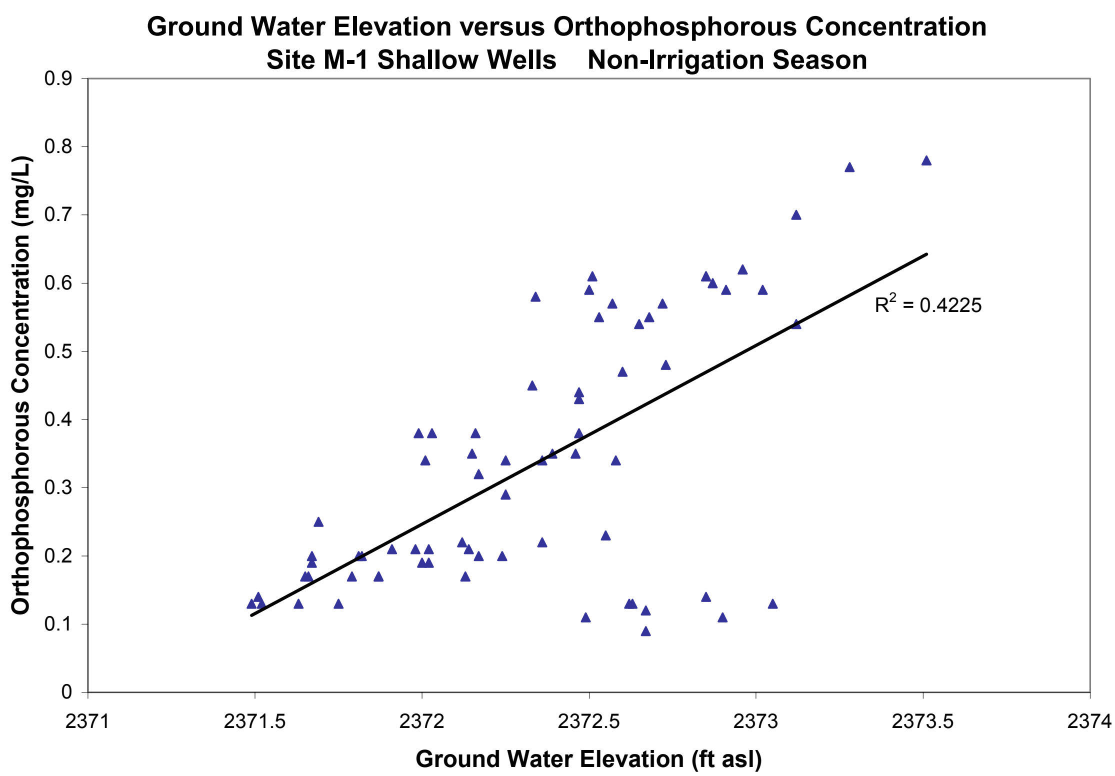

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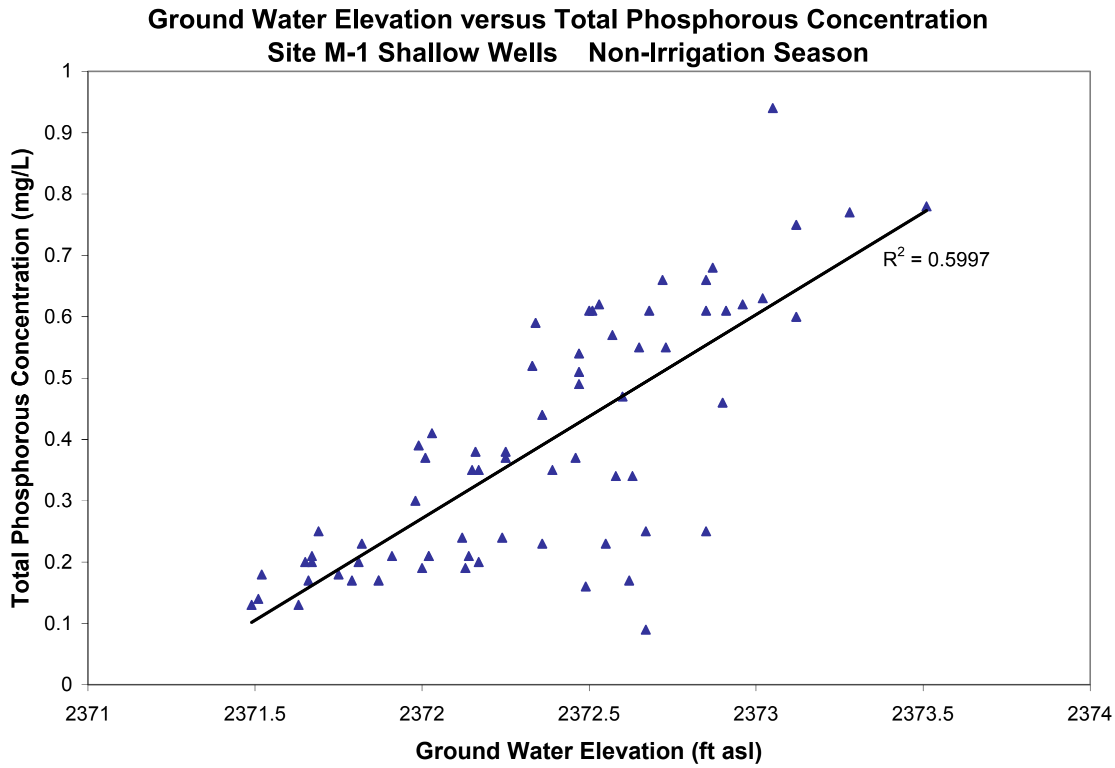
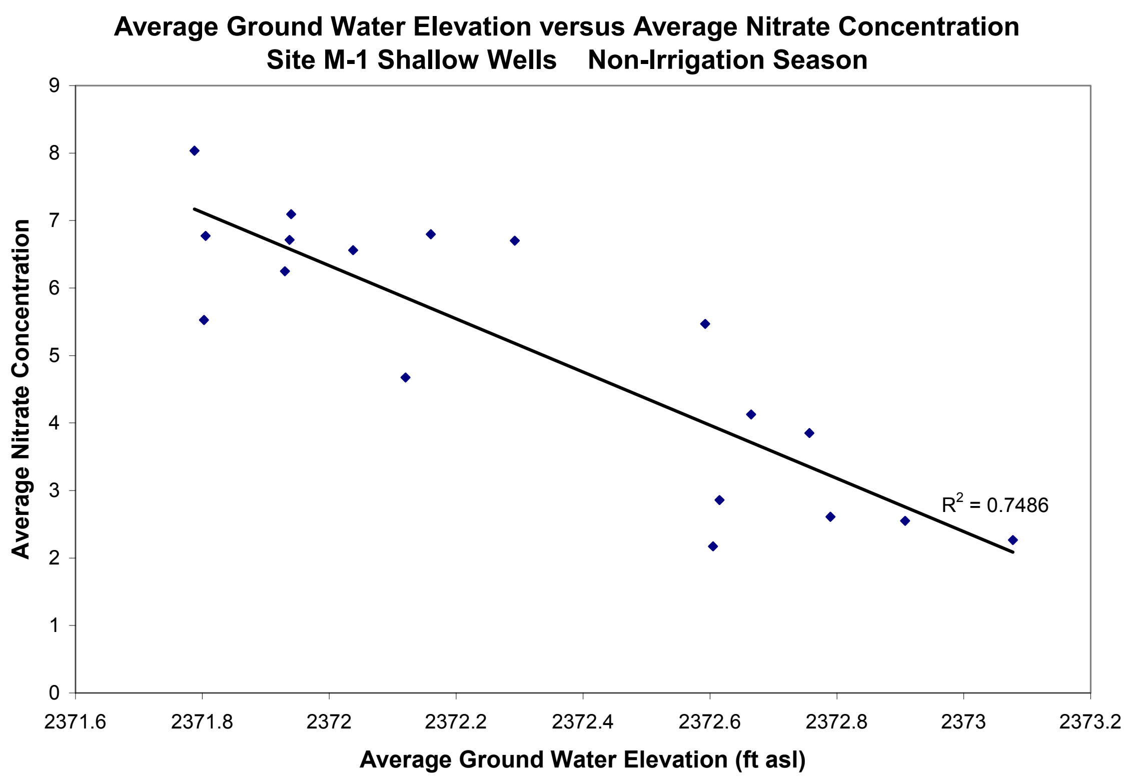
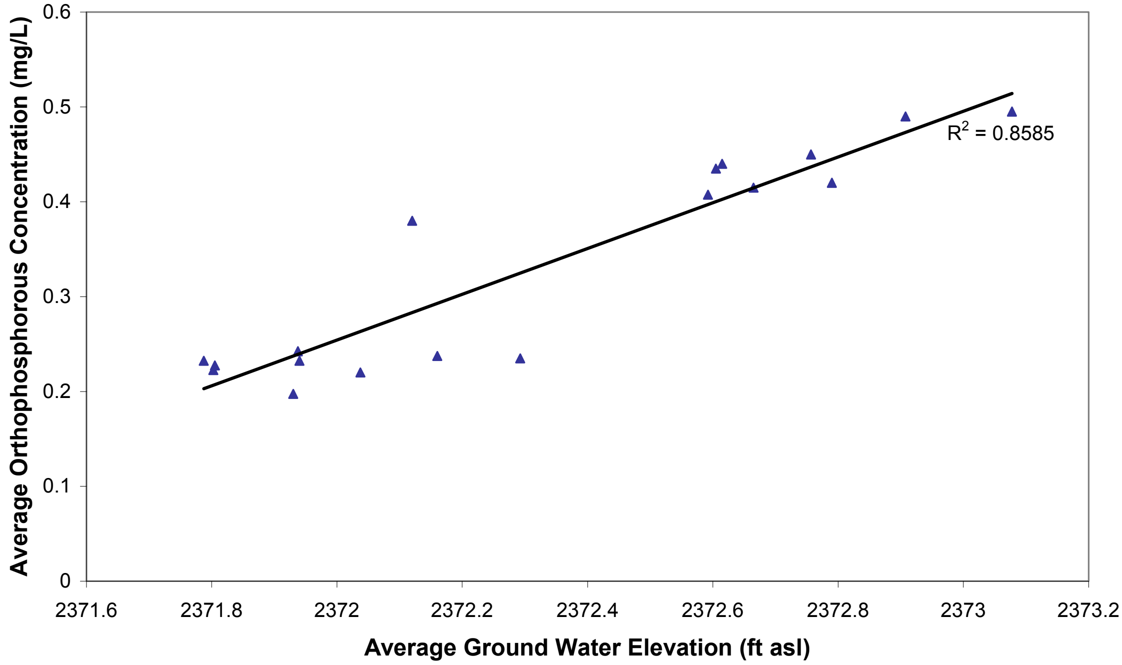


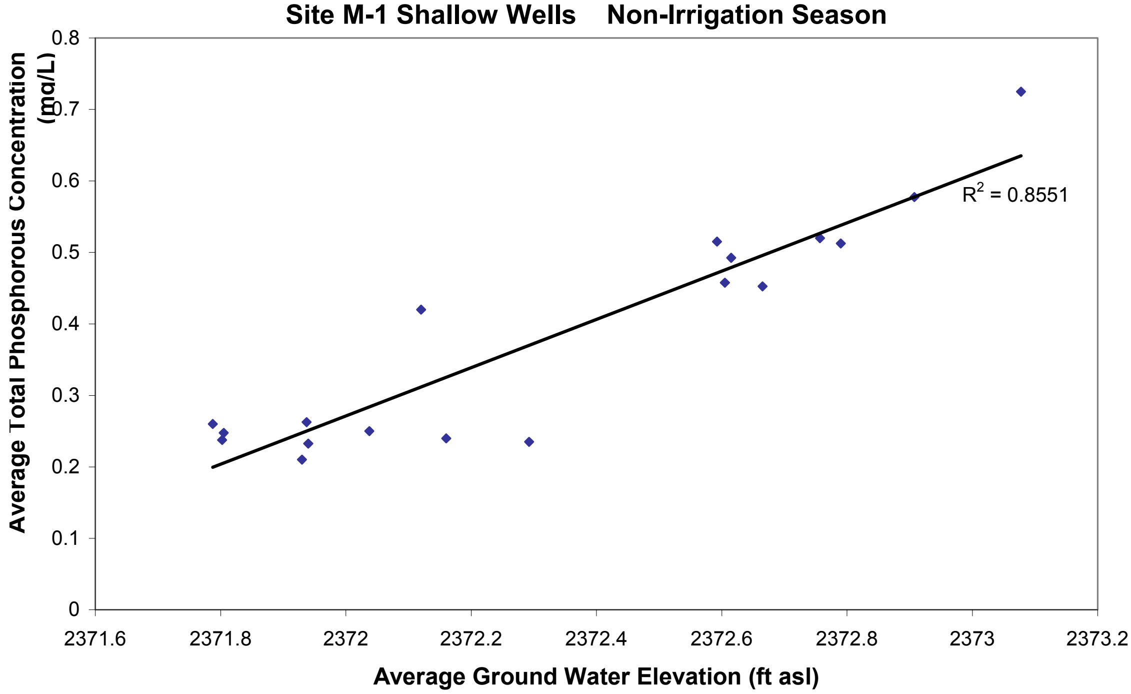


M-1 Regression Analysis Plots continued.

Average Ground Water Elevation versus
Average Orthophosphorous Concentration
Site M-1 Shallow Wells   Non-Irrigation Season

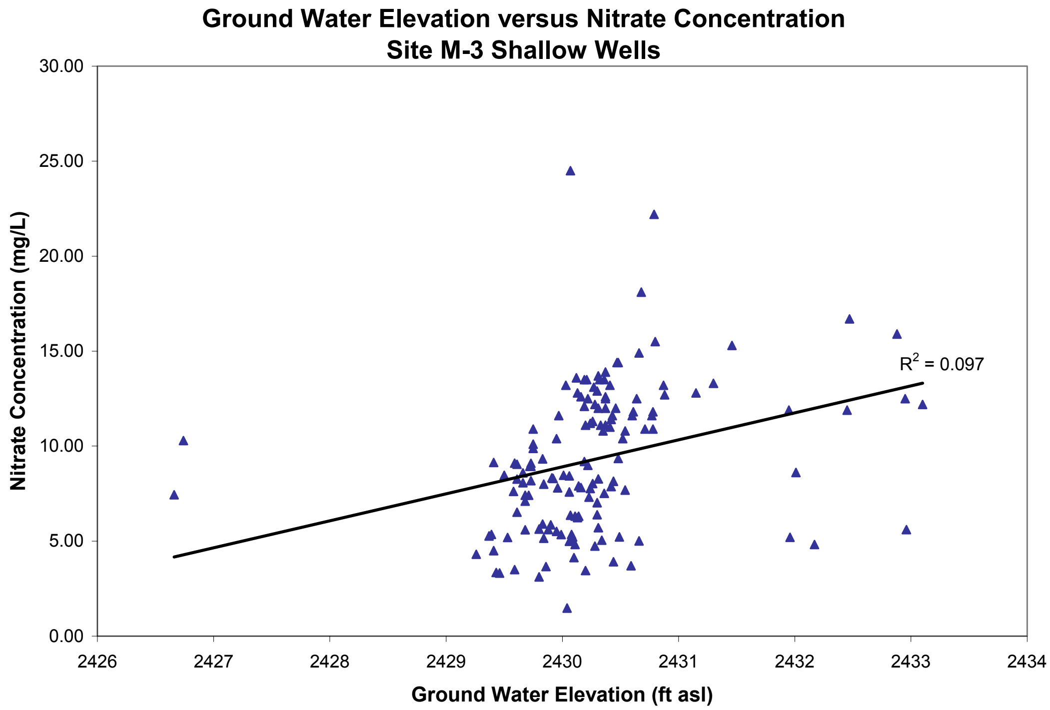


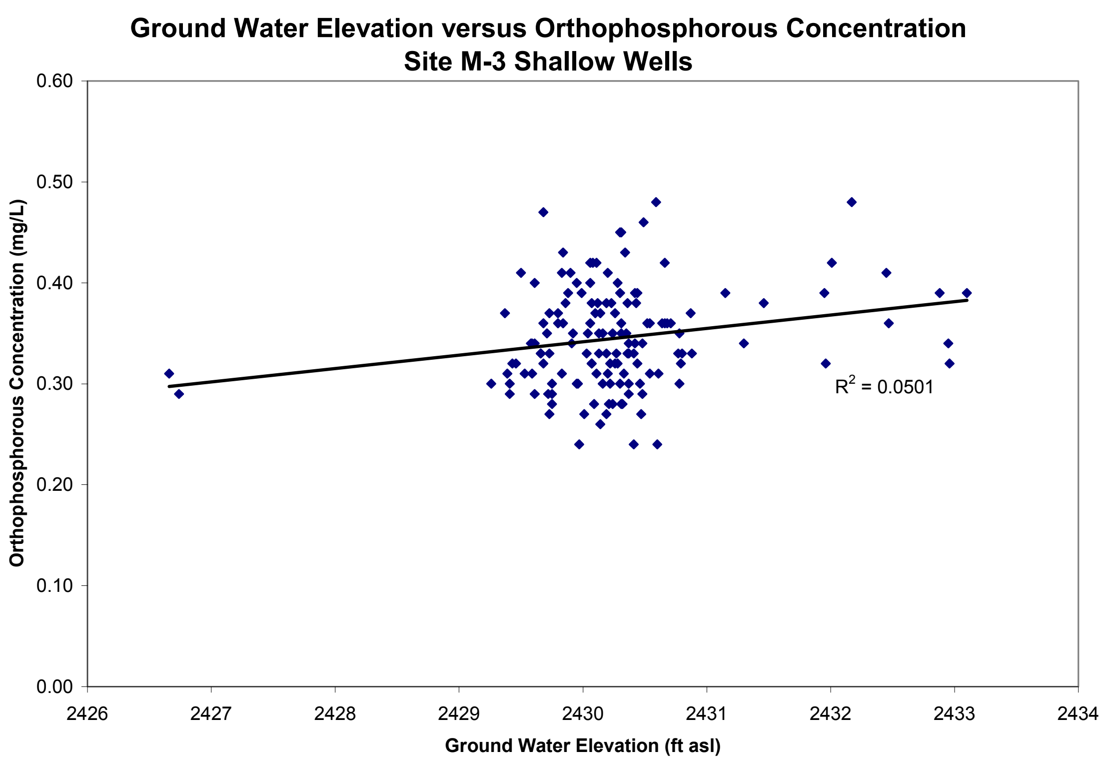
Average Ground Water Elevation versus
Average Total Phosphorous Concentration
Site M-1 Shallow Wells   Non-Irrigation Season



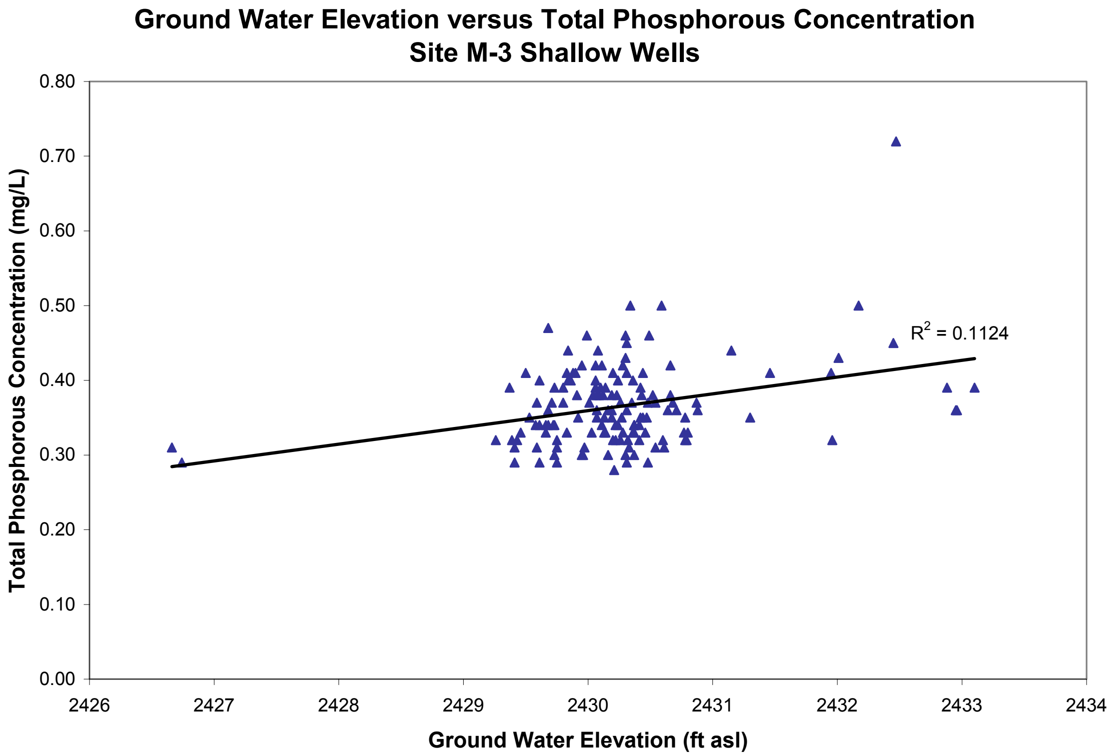
Regression Analysis Plots.

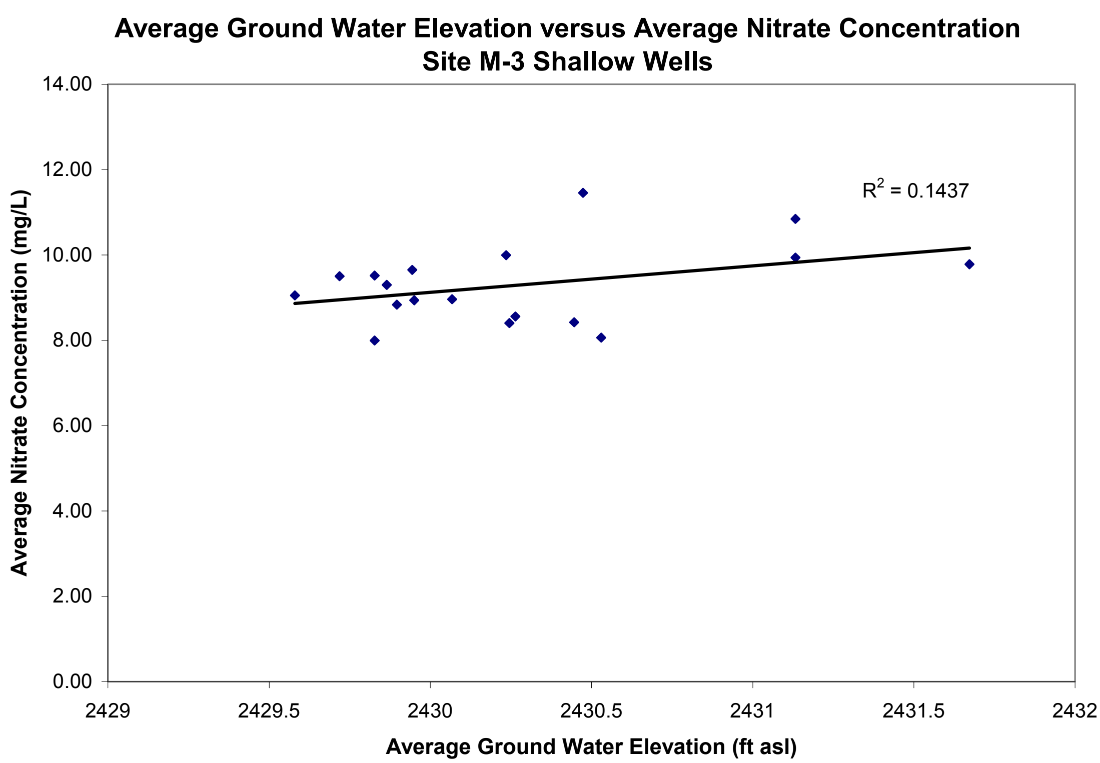
M-3



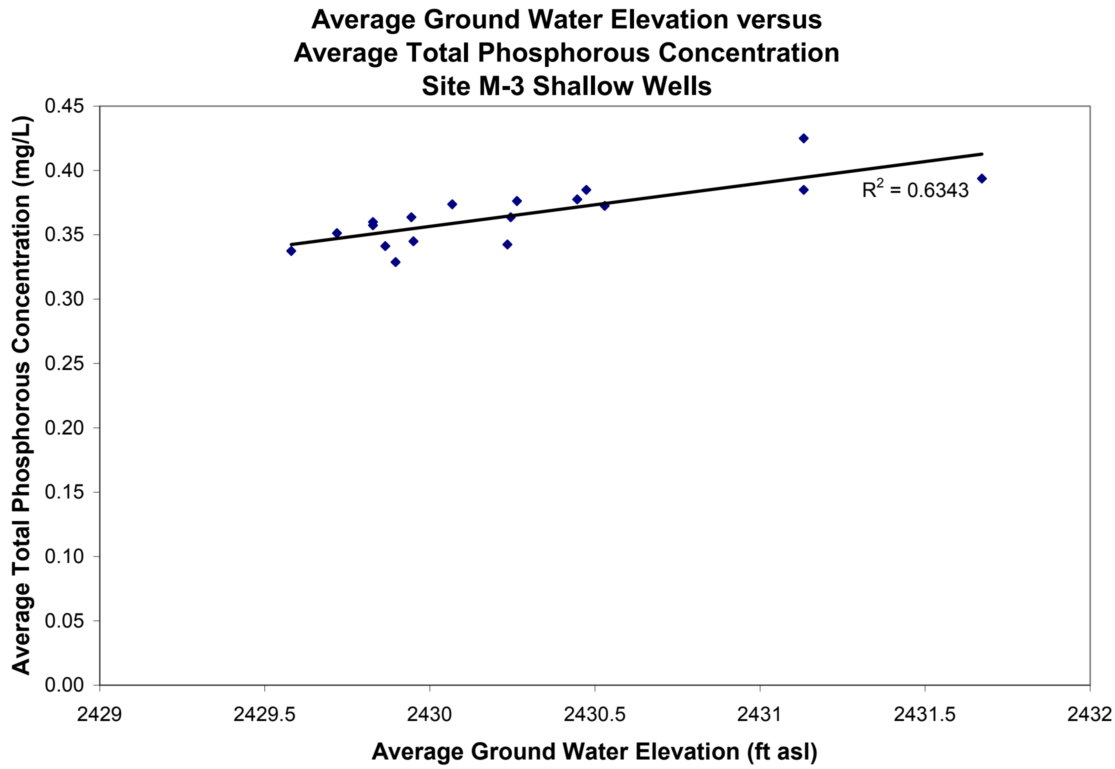


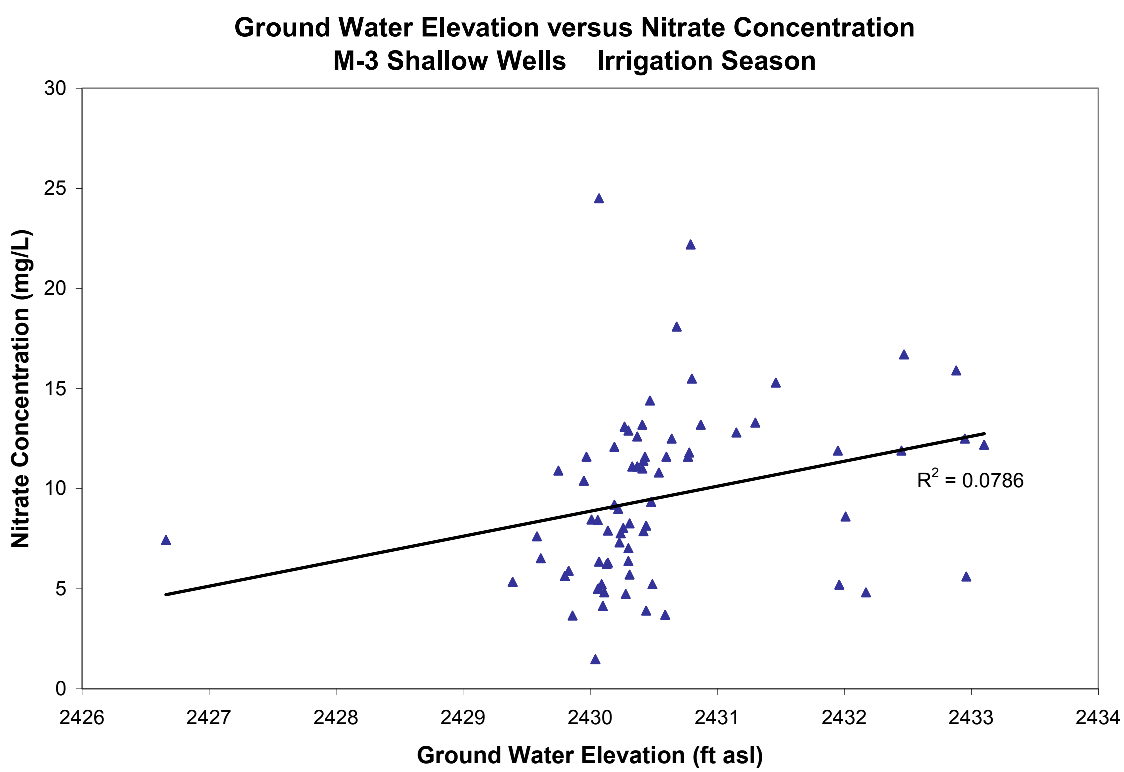
M-3 Regression Analysis Plots continued.



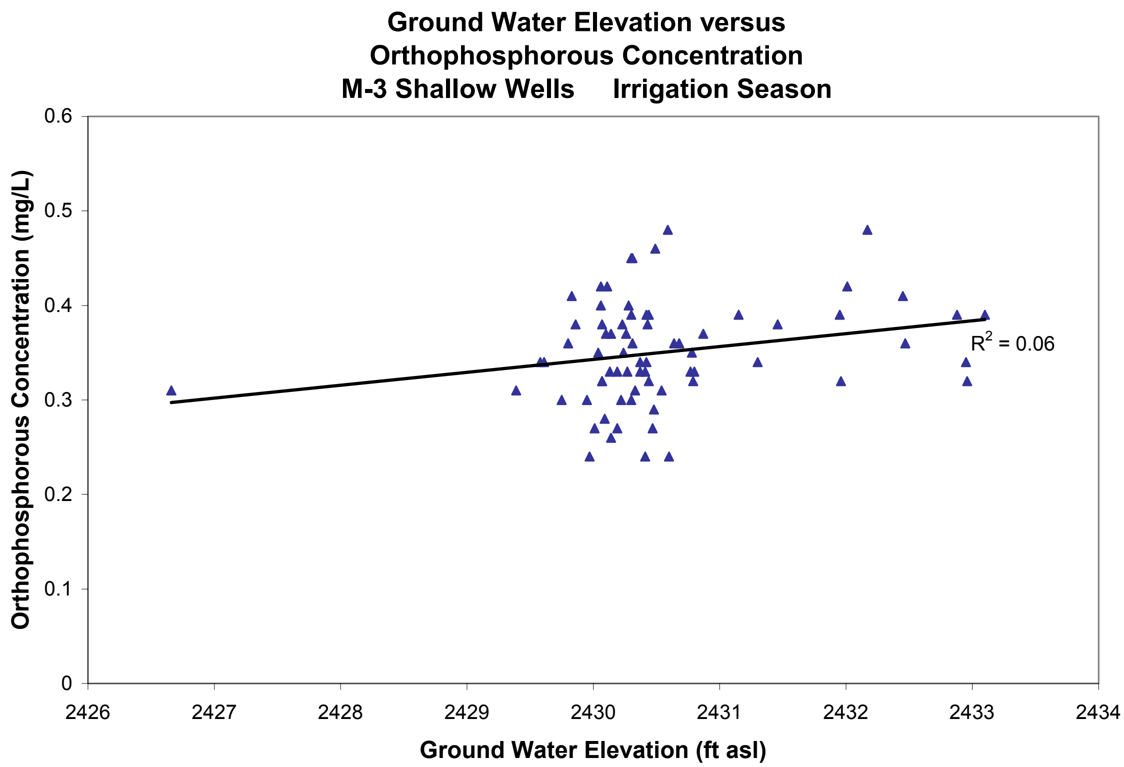


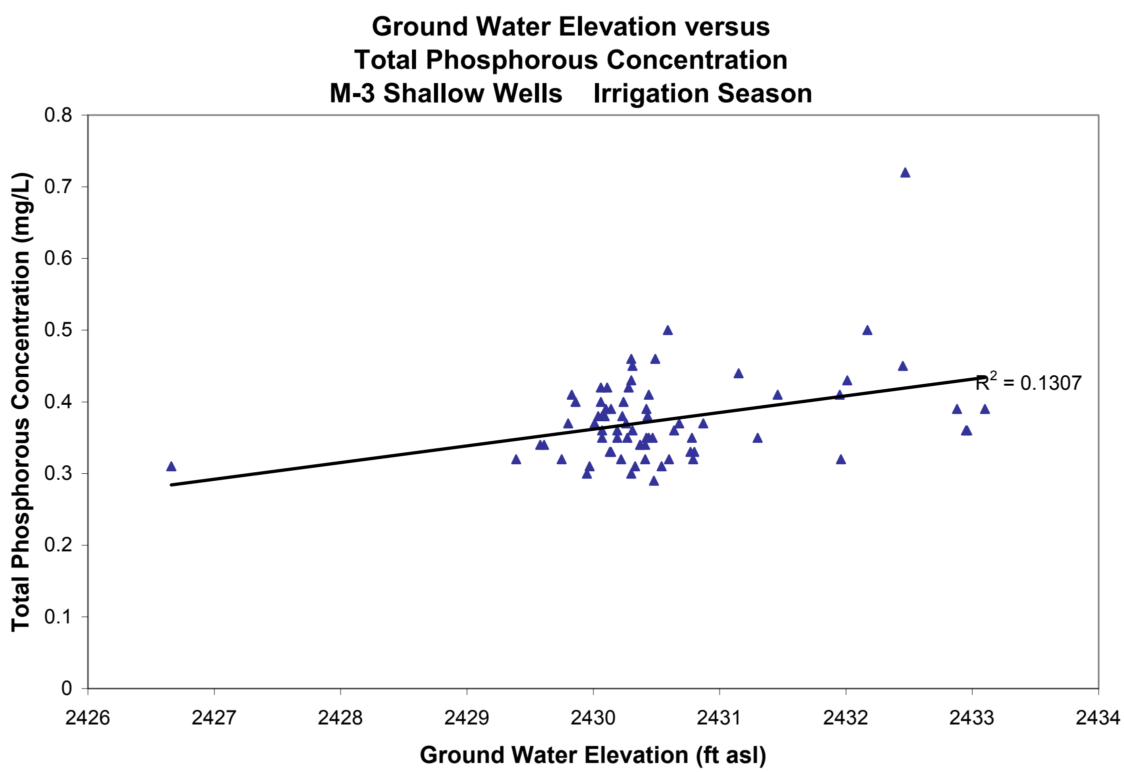
M-3 Regression Analysis Plots continued.





M-3 Regression Analysis Plots continued.





M-3 Regression Analysis Plots continued.